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# ASTM BULLETIN

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# ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545

R. E. Hess, Editor
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## Sessions on Statistical Quality Control and Non-Ferrous Atmospheric Exposure Tests to Feature Spring Meeting

### Sessions February 26 and 27; Committee Meetings all Week of Feb. 25 in Pittsburgh

A VERY wide segment of the A.S.T.M. membership will be interested in the technical sessions that will feature the 1946 A.S.T.M. Spring Meeting in Pittsburgh at the Hotel William Penn on February 26 and 27. On Tuesday evening under the auspices of the Pittsburgh District there will be two papers dealing with Statistical Quality Control, by two of the country's outstanding authorities, and on Wednesday afternoon and evening the Symposium on Atmospheric Exposure Tests on Non-Ferrous Metals and Alloys will be held, with several technical papers and discussions. This symposium is arranged by Committee B-3 on the Corrosion of Non-Ferrous Metals and Alloys. All members of the Society and others interested are cordially invited to attend these sessions.

Throughout the week beginning February 25 there will be in session morning, afternoon, and evening a large number of the technical committees of the Society and their subcommittees and sections. A detailed schedule of meetings was mailed to the members early in January together with a hotel form which those who plan to attend the meeting were urged to send back immediately to the Pittsburgh Convention Bureau which is arranging the hotel reservations. The Society is cooperating with the housing people in arranging for members to share twin-bedded rooms, which is necessary because of the very crowded hotel situation.

In planning for the Spring Meeting and Committee Week the Pittsburgh District has cooperated splendidly under the leadership of Thomas A. Spooner, Chairman, and P. G. McVetty, Secretary, both of Westinghouse Electric Corp.

STATISTICAL QUALITY CONTROL

The papers and discussions to be presented on the evening of February 26 come under a general heading, "Statistical Quality Control and Its Relation to Specifications." The first paper by Col. L. E. Simon, Head of the Ballistics Research Laboratory, Aberdeen Proving Grounds, is entitled "Dollars for Your Thoughts." An outstanding authority in this field with the much-desired faculty of getting his material across in readily understandable language, Col. Simon will undoubtedly have considerable food for thought for every A.S.T.M. member and committee member.

A companion paper providing a basis of discussion will be by Casper Goffman and Joseph Manuele, Staff Assistant and Director of Quality Control, respectively, Westinghouse Electric Corp., whose paper is "Use of Statistics in Writing Specifications."

Copies of these papers are being made available so that those who feel competent to provide discussion may have them in advance for study. A number of those concerned with this subject will be urged to participate in the meeting.

As announced in the December BULLETIN, a new A.S.T.M. Committee on Quality Control of Materials is in course of organization so that this session, sponsored by the Pittsburgh District, ties in with this development.

Attention is also directed to pages 60–62 of this BULLETIN in which there are published condensed abstracts of a number of more important publications in the field of statistics. Undoubtedly those members concerned will find the condensed reviews of much interest.

F. T. Mavis, Professor of Civil Engineering, Carnegie Institute of Technology, has been active for the District in connection with the development of this session.

SYMPOSIUM ON RESULTS OF ATMOSPHERIC EXPOSURE TESTS

From the titles of the papers to comprise the Symposium on Exposure Tests of Non-Ferrous Metals and Alloys, a good conception can be had of the general tenor of the two sessions. Furthermore, from the names of the authors it will be noted that some of the country's leading authorities in this field are participating. It is expected copies of these papers will be available in advance in mimeographed form and Headquarters may be able to fill a limited number of requests for them.

W. H. Finkeldey of Singmaster & Breyer, Chairman of Committee B-3, has been directing the Symposium, with Secretary A. W. Tracy, American Brass Co., and cooperating with them has been J. J. Bowman, Aluminum Company of America, representing the Pittsburgh District.

In general the purpose of the authors will be to bring out the salient information and data resulting from the very extensive atmospheric corrosion tests which Committee B-3 has carried out, in some cases for over ten years. Many of

these data have been published in the Society's *Proceedings*, notably in the annual reports of Committee B-3 and now there has been an opportunity to evaluate them so that American industry can better assimilate the results and make even more practical use of them.

The afternoon session will get under way at 2 p.m. promptly in the Urban Room of the Hotel William Penn, with the evening session scheduled for 7:30 p.m. Capacity audiences are expected at each.

The papers to be presented are as follows:

*Afternoon Session*

The Corrosion of Rolled Zinc in the Outdoor Atmosphere, E. A. Anderson, Chief of the Metals Section, Research Div., The New Jersey Zinc Co.

The Behavior of Nickel and Monel in Outdoor Atmospheres, W. A. Wesley, Assistant Director, Research Lab., The International Nickel Co., Inc.

Resistance of Copper Alloys to Atmospheric Corrosion, A. W. Tracy, Assistant Metallurgist, The American Brass Co.

*Evening Session*

Use of Lead and Tin Outdoors, G. O. Hiers, Chemist, Research Labs., National Lead Co.

The Resistance of Aluminum-Base Alloys to Atmospheric Exposure, E. H. Dix, Assistant Director of Research and Chief Metallurgist and R. B. Mears, Chief, Chemical and Metallurgy Div., Aluminum Research Labs., Aluminum Company of America.

Tracking Trouble in Atmospheric Corrosion Tests—W. E. Campbell, P. S. Olmstead, and H. G. Romig, Bell Telephone Laboratories Inc., New York, N. Y.

### A.S.T.M. Committee Week

While the schedule of technical committee meetings sent by direct mail to all committee members several weeks ago is designed to conserve time and avoid as many conflicts as possible, the very large number of meetings called by the groups makes it difficult to prepare a schedule so that full time can be given to the meetings and still work them in during the five days and nights available. Nevertheless, in general, this system works out splendidly, enabling members of different committees to concentrate their work in one trip. A final schedule including room assignments will be available at the A.S.T.M. registration desk on the 17th floor of the Hotel William Penn.

*There follows a list of the main technical committees meeting in Pittsburgh. Usually there are a number of subcommittees and sections of these also convening, in most cases prior to the main committee meeting time which is given.*

COMMITTEE WEEK,
FEBRUARY 25–MARCH 1

A-1 on Steel, Wednesday 9:30 a.m.

A-3 on Cast Iron, Tuesday, 4:00 p.m.

A-5 on Corrosion of Iron and Steel, Wednesday, 9:00 a.m.

A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, Tuesday, 4:00 p.m.

B-3 on Corrosion of Non-Ferrous Metals and Alloys, Tuesday, 4:00 p.m.

B-7 on Light Metals and Alloys, Cast and Wrought, Friday, 10:00 a.m.

B-8 on Electrodeposited Metallic Coatings, Friday, 10:30 a.m.

C-1 on Cement, Tuesday, 1:30 p.m.

C-7 on Lime, Thursday, 2:00 p.m.

C-9 on Concrete and Concrete Aggregates, Wednesday, 2:00 p.m.

C-16 on Thermal Insulating Materials, Wednesday, 6:30 p.m.

D-1 on Paint, Varnish, Lacquer and Related Products, Wednesday, 9:30 a.m.

D-3 on Gaseous Fuels, Tuesday, 10:00 a.m.

D-4 on Road and Paving Materials, Thursday, 2:00 p.m.

D-8 on Bituminous Waterproofing and Roofing Materials, Thursday, 9:00 a.m.

D-11 on Rubber and Rubber-Like Materials, Thursday, 2:00 p.m.

D-18 on Soils for Engineering Purposes, Friday, 8:00 p.m.

E-1 on Methods of Testing, Sections only.

E-3 on Chemical Analysis of Metals, Thursday, 9:00 a.m.

E-4 on Metallography, Subcommittee.

*The above schedule is subject to change. The notices sent out by the secretaries of the committees are to be considered the "last word."*

See page 52 for schedule of other meetings.

### Hotel Accommodations

Everything possible is being done to make sure that there will be sufficient hotel accommodations to take care of all of the members. In line with this, as the hotel return form stated, many of our members will be asked to share twin-bedded rooms and it is hoped suitable selections are being made by the housing bureau with the assistance of Headquarters.

# Annual Meeting Week Buffalo, June 24, to Be Intensive One

## Extensive Technical Program—Apparatus and Photographic Exhibits—Interesting Entertainment Program—Committee Meetings—Will Make Busy Time for Members

While it is at least partly correct to state that a "pre-war" type of meeting is in store for the membership in Buffalo, June 24 to 28, 1946, which connotes an extensive technical program, a number of interesting entertainment features for the ladies and members in attendance, and other events which go to make up the Annual Meeting, including a large number of committee meetings, we must hasten to add that the meeting is definitely post-war in concept since so many of the topics to be discussed in the technical sessions and the problems involving standards and research, which are current in the technical committees, are very much to the fore.

An interesting entertainment program is being considered by the Buffalo Committee on Arrangements, the nucleus of which is the Western New York-Ontario District Committee, with B. L. McCarthy, Wickwire Spencer Steel Co., Buffalo, Chairman; T. L. Mayer Department of Technology, Buffalo Public Library, Secretary; and Messrs. O. W. Ellis, Ontario Research

On the right—Albright Art Gallery, Buffalo, N. Y. Left—The Henry P. Werner, a lake freighter, Buffalo waterfront.

Foundation, Toronto, and P. C. Matthews, Eastman-Kodak Co., Rochester, Vice-Chairmen. Several small working groups of the general committee will be set up to supervise the various features of the meeting. There will be an advisory committee on the Apparatus Exhibit, and the Photographic Exposition will be largely run by the local subgroup which includes a number of photographic enthusiasts from the Buffalo area. In connection with the latter, members of the Society can expect to receive in March an entry blank which gives the rules and regulations for the exhibit. Those who care to submit prints can then make their plans well in advance. This Exhibit was one of the features of annual meetings prior to the war, with a number of outstanding entries, both professional and amateur. Many members and committee members are much interested in photography.

The Golf Committee will undoubtedly reinstitute the Annual Golf Tournament, and arrange to have the A.S.T.M. Championship Cup put up for play, as well as offering other prizes. There are several excellent courses in the Buffalo district including the Wanakah and the Park Club.

For ladies' entertainment, the committee will undoubtedly consider one or more bridge parties. A special tour of the Niagara Falls, including the Canadian Parkway system running from Lake Erie to Lake Ontario which might include a visit and luncheon at the General Brock Hotel, will be planned, possibly to include a visit to the famous Oakes Gardens.

### Exhibit of Testing Apparatus and Related Equipment

Many of the leading companies in the testing instrument, scientific apparatus, and laboratory supplies fields have applied for space in the Seventh Apparatus Exhibit to be held during the Annual Meeting on the Hotel Statler's Seventeenth Floor, which has a most excellent arrangement for the type of Exhibit the Society sponsors. This Exhibit, after a lapse of four years, will again enable the members to see outstanding developments in the instruments and laboratory supplies fields, and will afford the numerous exhibitors, many of them active in A.S.T.M. work, an opportunity to become acquainted with members and committee members at the meeting.

There will be a number of noncommercial displays, some to be suggested and developed by the Buffalo Committee on Arrangements, and an opportunity will be afforded the Society's technical committees to feature some of their work. Displays of this latter kind have been one of the interesting portions of previous exhibits.

It is probable these exhibits will open Monday noon, June 24, and will run daily thereafter through Friday, June 28. The official list of exhibitors and other details will be announced later.

### Technical Program

Some of the subjects which will be the basis of symposiums and sessions at the Forty-Ninth Annual Meeting were referred to in the December Bulletin. Additional details are given here.

Two symposiums which will be of widespread interest involve the Testing of Parts and Assemblies and the Fatigue of Materials. The first named will be sponsored jointly with A.S.T.M. by the Society for Experimental Stress Analysis. Subjects which undoubtedly will be covered relate to magnesium sheet alloys, service life of aircraft structures, turbine buckets, bronzes used for propellers, automotive rear axles, etc. The Symposium on Fatigue will include such topics as the strength of beryllium copper strip, notch sensitivity of some magnesium- and aluminum-base alloys, fatigue strength of wood, fatigue tests of steel at different hardness with different notches, and several others.

Committee C-9 on Concrete and Concrete Aggregates is particularly interested in developing a session or round-table on test methods of freezing and thawing concrete in connection with determination of durability. A special committee headed by W. F. Kellerman is developing a program and a number of authorities are participating. A great deal of research work is under way on this subject, and it is expected results from much of this will be available including a description of the various methods used.

The discussion which will form the basis of one or more sessions on Tools for Identification of Water Formed Deposits is under the auspices of Committee D-19, and it is planned to consider various types of equipment used, including biological and petrographic microscopes, the electron microscope, and other precision instruments. The

program as being developed would be one of an educational character, focusing attention on the instruments available and how information can be obtained on various deposits.

Still another symposium which will be of pertinent interest relates to pH. Under the auspices of a special committee functioning under Committee E-1 on Methods of Testing with L. B. Ashcraft, Westinghouse Electric Corp., chairman, papers are being developed which cover historical discussion, theoretical consideration, errors and corrections, electrode systems, indicators and colorimetric methods in both aqueous and nonaqueous media, and use of E.M.F. Measurements in the petroleum industry.

Other sessions at the meeting will be devoted to papers on the effect of temperature on the properties of metals, non-ferrous metals and alloys, and others.

While still to be confirmed, it is expected that the Buffalo Committee on Arrangements will plan for a dinner on Wednesday evening, June 26, with an outstanding speaker and one or two other features. The committee believes it would be quite worth while to get the members and their families together at dinner.

### Hotel Reservations

While a hotel reservation form will be sent each member in the near future, those who may wish to write now for accommodations can address A.S.T.M. Housing Bureau, Convention and Tourist Bureau, Inc., 602 Genesee Building, Buffalo, N. Y.

# Standards Committee Acts on Many Specifications and Tests

## Great Number of Recommendations from Technical Committees Results in "Annual Meeting in Miniature"

So many recommendations on new and revised specifications and test methods have been referred recently to the Administrative Committee on Standards that one might say there has been almost an annual meeting in miniature. From the accompanying extensive table listing all of these actions it will be seen that there has been intensive activity in many of the committees.

While each ASTM Bulletin lists the actions taken by the Administrative Committee on Standards (formerly Committee E-10), those covered in the accompanying list and briefly described in the following article are the most numerous that have gone through.

Most of the revised specifications and test methods will appear in their latest form in the 1945 Supplements to the Book of Standards which are practically completed. Some of the recommendations, however, were approved after the books had been released for press so that it was not possible to get these in. However, copies of the revised specifications will be available soon in separate pamphlet form.

With so many standards involved, it is impossible in this Bulletin to give an adequate picture of the new material, revisions, etc., but it is hoped what follows will be of interest to the members.

### *Chrome-Molybdenum Steel Pipe for High-Temperature Service:*

Due to the failure of carbon-molybdenum alloy-steel pipe which had been made essentially in line with existing Specifications A 206, Committee A-1 on Steel considered the best method of establishing a composition which would tend to inhibit graphitization. The formation of chainlike graphite in the weld affected zone of carbon-molybdenum pipe apparently resulted in the failure, and graphitized carbon was found in a number of other piping installations, particularly where used at temperatures above 950 F. Based on exhaustive research, a large number of technical papers, and numerous meetings, this new specification, providing for $\frac{1}{2}$ per cent molybdenum, $\frac{1}{2}$ per cent chromium was agreed upon as the best grade to inhibit formation of graphite. While it is expected that considerable material will be produced in accordance with this new tentative, the committee is continuing its studies of the use of steels at elevated temperatures and other compositions may find application.

### *Electrical Heating and Electrical Resistance Alloys*

Of the eight recommendations submitted by Committee B-4 on Electrical Resistance, Heating and Furnace Alloys three are new tentatives as indicated in the accompanying table. The Test for Strength of Welded Joints of Lead Wires for Electronic Devices and Lamps (B 203) has been in the process of development for over a year. The test is made under applied bending and involves rigidly clamping a specimen of lead wire immediately below and adjacent to the weld knot, enclosing the upper wire in a pair of knife edges oppositely disposed, and applying a bending force to the wire manually through the lever arm to which the upper knife edges are attached.

The Test for Surface Flaws in Tungsten Seal Rod and Wire (B 204) is intended to determine the presence of surface flaws in tungsten seal rod and wire of random or cut lengths, and in the tungsten section of multiple piece through leads used in electronic devices, by means of examination of a glass bead sealed to the tungsten.

To determine wire diameter by weighing methods (B 205), a torsion balance or other very accurate type is used. This covers wire too fine to be measured directly with sufficient accuracy by micrometers, and refers more particularly to wire up to 0.005 in. in diameter or thickness used in lamps and electronic devices.

The revision in the alloy casting specification B 190 merely involves

the addition of an appendix giving a number of significant bibliographic references which would provide information about the complex behavior of metals under stress at elevated temperatures. The committee does not assume that the bibliography is complete, but it does serve as an introduction to the subject.

The revisions in the Specifications for Round Nickel Wire (B 175) provide that the elongation is to be determined in a gage length of ten inches with the value to be not less than 30 per cent. There is some added material referring to the bend test.

The revised Test for Temper of Strip and Sheet Metals used in Electronic Devices (B 155) is to cover metal in thicknesses from 0.020 instead of the former 0.010 restriction and the length of the test specimen is now to be a matter of agreement between producer and user.

*Electrical Conductors:*

The changes in the Test for Resistivity of Copper (B 193), while extensive, are primarily editorial, and clarifying in nature. They were developed by a small task group which was appointed by Committees B-1, B-4, and B-5, which groups are concerned with companion tests for resistivity of metallic materials in the jurisdiction of Committee B-4. Eventually, to clarify B 193 and B 63 the former may be rewritten as a test for conductivity, but this will develop later.

*Copper and Copper Alloys, Cast and Wrought:*

Among the large number of recommendations submitted by Committee B-5 are new Tentative Specifications for Copper-Nickel-Zinc Alloy Wire (B 206 – 46 T), requirements for which were previously set up in the Specifications B 151 covering rod, bar, and wire, and which are now to be removed. Three alloys are provided with nominal copper compositions of 65, 55, and 62 per cent; zinc, 17, 27, and 19 per cent, respectively, with nickel in all three cases at 18. Class A is for general use; B for hard or spring temper; and C where ease of machining is important.

A general statement on the numerous tentative revisions of standards and revisions of tentatives recommended by the committee should include the fact that in several cases standard rejection clauses are being incorporated; in some the CABRA (Copper & Brass Research Association) standard edge contours are to go in; in other cases revised tolerances developed in cooperation with CABRA will be incorporated. In some specifications notes will be included listing data on density of the various alloys covered.

## Actions by the Administrative Committee on Standards, December, 1945–January, 1946

### New Tentatives

*Specifications for:*

Seamless Chromium-Molybdenum Alloy-Steel Pipe for Service at High Temperature (A 280 – 46 T)
GR-S Synthetic Rubber Sheath Compound for Electrical Insulated Cords and Cables (D 865 – 46 T)
Copper-Nickel-Zinc Alloy Wire (B 206 – 46 T)

*Method of:*

Chemical Analysis of Copper and Copper-Base Alloys (E 62 – 46 T)
Chemical Analysis of Refined Copper (E 53 – 46 T). Revision of Method B 34 – 36 T
Test for Coefficient of Cubical Expansion of Plastics (D 864 – 45 T)
Designating the Flow Temperature of Thermoplastic Molding Materials (D 863 – 45 T)
Test for Strength of Welded Joints of Leaded Wires for Electronic Devices and Lamps (B 203 – 45 T)
Test for Surface Flaws in Tungsten Seal Rod and Wire (B 204 – 45 T)
Determination of Wire Diameter by Weighing (B 205 – 45 T)
Test for Evaluating Treated Textiles for Permanence of Resistance to Microorganisms (D 862 – 45 T)

*Recommended Practice for:*

Yarn Numbering (D 861 – 45 T)

### Tentative Revisions of Standards

*Specifications for:*

Insulated Wire and Cable: Heat Resisting Rubber Compound (D 469 – 41)
Copper Rods for Locomotive Staybolts (B 12 – 45)
Free-Cutting Brass Rod and Bar for Use in Screw Machines (B 16 – 45)
Copper Water Tube (B 88 – 45)
Copper-Silicon Alloy Wire for General Purposes (B 99 – 45)
Copper-Silicon Alloy Rods, Bars and Shapes (B 98 – 45)
Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock (B 111 – 45)
Brass Wire (B 134 – 45)
Manganese Bronze Rods, Bars and Shapes (B 138 – 45)
Leaded Red Brass Rods, Bars and Shapes (B 140 – 45)

*Method of:*

Testing and Tolerances for Single Jute Yarn (D 541 – 41)
Testing Wool Felt (D 461 – 45)

### Revision of Standard and Reversion to Tentative

*Method of:*

Test for Fastness of Colored Textiles to Light (D 506 – 41)
New Designation (D 506 – 45 T)

### Revision of Tentatives

*Specifications for:*

Insulated Wire and Cable: Heat-Resisting Synthetic Rubber Compound (D 754 – 46 T)
Insulated Wire and Cable: Performance Synthetic Rubber Compound (D 755 – 46 T)
Cellular Rubber Products (D 798 – 46 T)
Naval Brass Rods, Bars and Shapes (B 21 – 46 T)
Seamless Copper Tubes (B 75 – 46 T)
Copper-Nickel-Zinc and Copper-Nickel Alloy Sheet and Strip (B 122 – 46 T)
Copper Rods, Bars and Shapes (B 133 – 46 T)
Miscellaneous Brass Tubes (B 135 – 46 T)
Phosphor Bronze Rods, Bars and Shapes (B 139 – 46 T)
Aluminum Bronze Rods, Bars and Shapes (B 150 – 46 T)
Copper-Nickel-Zinc Alloy Rod and Bar (B 151 – 46 T)
Phosphor Bronze Wire (B 159 – 46 T)
Beryllium-Copper Alloy Strip (B 194 – 46 T)
Beryllium-Copper Alloy Rod and Bar (B 196 – 46 T)
Beryllium-Copper Alloy Wire (B 197 – 46 T)
Molds for Test Specimens of Molding Materials Used for Electrical Insulation (D 647 – 45 T)
Phenolic Molding Compounds (D 700 – 45 T)
Chromium-Nickel-Iron Alloy Castings for High-Temperature Service (B 190 – 45 T)
Round Nickel Wire for Lamps and Electronic Devices (B 175 – 45 T)

*Methods of:*

Test for Changes in Properties of Rubber and Rubber-like Materials in Liquids (D 471 – 46 T)
Testing Cellular Rubber Products (D 552 – 46 T)
Test for Resistivity of Copper and Copper-Alloy Electrical Conductors (B 193 – 45 T)
Test for Deformation under Load of Plastics (D 621 – 45 T)
Test for Temper of Strip and Sheet Metals for Electronic Devices (B 155 – 45 T)
Testing Wire for Supports Used in Electronic Devices and Lamps (B 157 – 45 T)
Test for Density of Fine Wire and Ribbon for Electronic Devices (B 180 – 45 T)
Test for Resistance of Textile Fabrics to Microorganisms (D 684 – 45 T)
Testing and Tolerances for Spun, Twisted, or Braided Products Made from Flax, Hemp, Ramie, or Mixtures Thereof (D 739 – 45 T)
Test for Resistance of Textile Fabrics and Yarns to Insect Pests (D 582 – 45 T)
Testing and Tolerances for Rope (D 738 – 45 T)

*Definition of:*

Terms Relating to Textile Materials (D 123 – 45 T)

### Revision of Emergency Standard

*Method of:*

Test for Sulfated Residue from Lubricating Oils by Air Ignition (ES – 43)

### Withdrawal of Emergency Alternate Provisions

*Specifications for:*

Insulated Wire and Cable: Performance Rubber Compound (EA – D 353)
Insulated Wire and Cable: Heat-Resisting Rubber Compound (EA – D 469a)
Rubber Sheath Compound for Electrical Insulated Cords and Cables (EA – D 532a)

*Petroleum Products and Lubricants:*

In continuing the Emergency Methods for the Determination of Sulfated Residues of Lubricating Oils (ES – 43), Committee D-2 is cognizant that some further cooperative tests are under way which it is hoped may result in having the emergency changed to the status of a regular tentative later in the year. The method is intended for the determination of residue from new and used lubricating oils and from additive concentrates and it may be used to indicate the concentration of known metal-containing additives in new oils.

*Rubber and Rubber-Like Materials:*

It will be noted that in addition to numerous revisions, Committee D-11 on Rubber and Rubber-Like Materials is withdrawing several emergency provisions which are applicable to insulated wire and cable.

The new Tentative Specifications for GR-S Synthetic Rubber Sheath Compound for Electrical Insulated Cords and Cables (D 864) is virtually identical with the Emergency Specifications ES – 6, but it is recommended that this GR-S compound be limited in service which requires flexing to temperatures above −25 C. Similarly, the revisions in the wire and cable specifications D 754 and D 755 will indicate that they are not recommended for installations or use in severe service at temperatures lower than −35 C. This synthetic compound gets stiff and brittle when too cold. Another change is the increase for duration of the high voltage test from one minute to five minutes.

The heat-resisting compound specification D 469 incorporates a new table of insulation resistance requirements.

The change in Methods of Testing Properties in Liquids (D 471) modifies the tolerance in aniline point for certain base oils used in the test. The aniline point is indicative of the swelling characteristics of oils and must be more closely controlled to give reproducible results. While the revisions in the Methods of Testing Cellular Rubber Products (D 552) are not major in extent, involving a reference to the cutting die for samples and minimum size of flexing plate, this situation is not true with the Specifications for Cellular Rubber Products (D 798) where the revisions are very extensive, particularly affecting the tables which cover characteristics of the rubbers.

*Textile Materials*

Of the two new tentatives developed by Committee D-13, one is in a field of activity where considerable other work has been done, namely, the effect on textiles of microorganisms. The new method for evaluating the permanence of treated textiles (D 862) has been preceded by methods for determining resistance (D 684) and evaluating compounds used to increase the resistance (D 627). The new methods set up conditions simulating ordinary service. The other new tentative (D 861) which is a recommended practice for the system of yarn numbering, was covered in some detail in the ASTM BULLETIN and is the Grex yarn numbering system. It is applicable to various materials including fibers, yarn intermediates, cords and threads, in addition to yarns.

Several existing tentatives covering textile materials were revised and tentative revisions were approved in certain standards as indicated in the table.

*Plastics:*

The new test for Coefficient of Cubical Expansion of Plastics (D 863) applies to both rigid and nonrigid plastics. Under conditions of industrial applications, the thermal expansion of a plastic is composed of a reversible component on which are superimposed changes in volume due to changes in moisture content, curing (degree of polymerization), loss of plasticizer or solvents, release of stresses, and other factors. This method of test is intended for determining the reversible cubical thermal expansion with the exclusion of these accidental factors.

Changes in the Tentative Test for Deformation under Load of Plastics (D 621) consist principally of the addition of methods of conditioning. Statements are included describing what each type of condition means in terms of shrinkage and flow. Changes in the Tentative Specifications for Phenolic Molding Compounds (D 700), which is a joint Committee D-20, D-9 specification, involve modified requirements for some of the materials covered. By incorporating the revisions a larger number of materials falling essentially in the same type classifications is included and thus the user has a greater range of materials from which to make a selection, particularly with respect to moldability and general shop performance.

The only change covered in the revised Specifications D 647 is the elimination of the five-bar mold for molding the ½ by ½ by 5-in. test specimen. Committee D-20 now has jurisdiction of these specifications which were formerly covered by Committee D-9 on Electrical Insulating Materials.

*Chemical Analysis of Metals:*

Committee E-3 on Chemical Analysis of Metals constantly is striving to improve the very widely used standard procedures which it has issued and from time to time issues new methods covering determination of the different elements. The method of photometric analysis of copper and copper-base alloys (E 62) gives procedures for determining nickel and phosphorus. These are up-to-date methods based on a color reaction and subsequent measurement of the color with a photometer.

The methods of chemical analysis of refined copper (E 53), essentially a revision of the former methods B 34, bring the various procedures up to date. No changes had been made in these methods for many years. They cover the electrolytic determination of copper in copper having a purity of 99.40 per cent and over. They are applicable to electrolytic copper, lake copper, and low-grade or casting copper. In these methods silver is deposited with the copper, and is weighed and reported as copper.

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# From Research—New Knowledge, New Materials, New Methods[1]

## By T. A. Boyd[2]

President Townsend's address, to which this was presented as a companion paper at the Chicago District Meeting, had the title, "Research Revolutionizes Materials." And research does indeed revolutionize materials. When, all within the space of a few months after the supply of natural rubber had suddenly failed, the vital need was filled with synthetic rubbers; when one of those synthetics, butyl rubber, makes inner tubes for tires which hold air ten times as well as tubes of natural rubber; when sulfa drugs and penicillin are discovered to be so utterly marvelous as they are for controlling infections; when aviation gasoline is so changed in composition that airplane engines in World War II could give three to four times as much power per unit of displacement as was so in World War I; and when, in the course of producing the atomic bomb, entirely new chemical elements were produced, that is surely revolution in materials.

### Progress Demands Much Research

The illustrations of materials which have been originated or radically changed through research, as just cited, are of course only a few out of many. But here is an important thing that needs to be realized and emphasized: Materials are not originated or changed *except* through research. The several developments cited came into being only through an immense amount of experimentation. Think of all the millions of man hours of investigation and experimentation required to give us the knowledge of how to make and to utilize synthetic rubbers. Even before the intensive activity of the war period, the figure was given as three million man hours, and the success of synthetic rubber was built in turn upon the extensive foundation of know-how in the field of natural rubber laid by years of prior effort; or take the high-octane gasoline which did so much to help win the war just closed—the same immensity of experimental effort had to be expended there.

And so, in manner of accomplishment, improvements come mostly not by *revolution* but through slow, patient, research-directed *evolution*. The realization of this in the industrial world is one of the primary reasons why, now that the war is over, there is bound to be a large expansion in the field of industrial research—an expansion which will be common to many, many organizations. It is why you have seen in the press that such companies as the Bell Telephone Laboratories, The General Electric Co., the Standard Oil Co. of Indiana, General Motors Corp., and many others are greatly extending their facilities for doing research.

It is important to realize, too, that advances do not always come from research aimed directly at making those particular advances. Because improvements may and do come about in altogether unexpected ways, one important function of a research staff is to be on the lookout for developments in fields other than their own which may have application in theirs. This is why Mr. Kettering said a long time ago that it is a mistake to close the doors of a research laboratory, for in doing so you may shut out more than you shut in.

### Events in the Evolution of Synthetic Finishes

A classical story of the tortuous course over which advances are sometimes reached is this one about events which led up to synthetic finishes for automobile bodies. Back in 1910 rubber cost \$3 a pound. A small tire sold then for \$35. A big tire cost \$125, \$500 for a set, and they ran only 5,000 miles at that.

It is thus not strange that at that time people should have been trying hard to find out how to make synthetic rubber. The best starting materials for the rubber synthesis appeared to be the two hydrocarbons, butadiene and isoprene, and it was known that butadiene could be made from butyl alcohol.

Just as that time a discovery of importance to the endeavor was made. A microorganism was found which would ferment starch, not into the customary ethyl alcohol alone, but into a liquid of which each 10 gal. contained 6 gal. of butyl alcohol, 3 gal. of acetone, and only 1 gal. of ethyl alcohol. This new ferment was given a long scientific name, of course, but in common language it was called the "butyl bug." Because it would make the butyl alcohol needed in the search for synthetic rubber, its habits were studied with the minutest care.

Then in 1914 came World War I, and with it a huge demand for powder. The acetone needed for the smokeless powder produced in England had always been procured as a by-product in making charcoal out of wood. But now the amount of powder required was so huge that the wood distillers could not possibly make enough acetone to supply it. In this emergency, the "butyl bug" was put to work converting starch into acetone. The two gallons of butyl alcohol which it made for each one gallon of acetone was then a useless by-product which was disposed of in whatever way possible.

Next the United States got into the war. When President Wilson ordered all whisky distilleries to shut down, as he soon did, one distillery with an experimental-minded manager continued to operate. I mean it continued to operate openly, as

[1] Presented at the Chicago A.S.T.M. District Meeting, October 24, 1945.
[2] Head, Fuel Dept., Research Labs. Div., General Motors Corp., Detroit, Mich.; Vice-President, A.S.T.M., and Chairman, Technical Committee D-2 on Petroleum Products and Lubricants.

distinguished from those which went underground or into back alleys. It did so by changing the ferment used from yeast to the new "butyl bug." Instead of disposing of the by-product butyl alcohol, the manager there built a large concrete vat to store it in with the hope that some good use for it would be found.

And, after the war, a use was found for all that stock of butyl alcohol. Chemical manufacturers had huge stores of nitrocellulose left over from wartime and automobile makers were searching for a better finish for cars than paint. About that time some experimenter discovered how to make concentrated solutions of nitrocellulose that were free-flowing enough to be sprayed on automobile bodies. Under that combination of events, an immense amount of experimentation was undertaken within the automobile industry on making it possible to apply lacquer finishes to car bodies in practice. And, when after long experiment the problems of such application were solved, there was a demand for a solvent with properties suitable for the purpose. And then that stock of butyl alcohol became very valuable indeed. For butyl alcohol is easily converted into butyl acetate, a wonderful solvent which, in the absence of the wide diversity of solvents developed since, proved to be indispensable in the development of synthetic finishes. Thus it was that in large part synthetic finishes for cars came in a round-about way out of research and experimentation in World War I and before.

The value of synthetic finishes as a substitute for paint on automobile bodies was not limited at all to the better and more durable finishes of themselves, large though that improvement was. They proved to be of great importance also in reducing the cost of making cars. By cutting the time required to finish an automobile body from days to hours, as they did, the number of bodies in process could be kept small enough to make possible the mass production of closed bodies. Without fast-drying finishes, the space required for finishing closed bodies in such large numbers as have since been built would have been well nigh prohibitive.

Now the man who made the discovery of the "butyl bug" was Dr. Chaim Weizmann, a professor at the University of Manchester in England. So outstanding was the service it rendered to Britain by solving an acute problem in relation to the powder supply that the Prime Minister, Lloyd George, sent for Professor Weizmann. "You, sir," he said, "have rendered a great service to the nation, and I should like to commend you to His Majesty for some appropriate honor."

"There is no honor that I want," replied Professor Weizmann, "but I should like you to do something for my people." He then told Lloyd George of the aspirations of himself and others to make Palestine once again the home of the Jewish people. The result was that soon the British Foreign Secretary issued the famous Balfour Declaration, which document became the great charter of the Zionist movement. And that too came out of a discovery made without any such outcome in view. So in this respect the circuitous route by which improvements are sometimes made is no different from the way other events happen.

## How High-Octane Gasolines Came to Be

One place where large improvements in materials have been made, and of which it seems especially fitting for me to speak, is in the petroleum field. It is particularly appropriate, too, to mention this subject here in Chicago, where there are so many who have made contributions to the improvements spoken of.

An outstanding instance of improvement in the field of petroleum is the high-octane aviation gasoline which did so much to help win the war just closed. "I think we wouldn't have won the Battle of Britain without 100-octane," said Geoffrey Lloyd, Great Britain's petroleum secretary. But, as luck would have it, British fliers did have 100-octane then. And our pilots too had it throughout the war. 100-octane aviation gasoline was mostly an American development, of course, and more than four fifths of that used in the war was made here.

What a big boost in engine power the high-octane gasoline used in World War II permitted by comparison with the gasoline used in World War I is seen in the comparison of aircraft engines in the two wars:

| Liberty Engine World War I | | Allison Engine World War II |
|---|---|---|
| 400 | Horsepower | 1500 |
| 12 | Number of Cylinders | 12 |
| 1650 | Piston Displacement | 1710 |

Here it is seen that, although these engines had the same number of cylinders and were almost the same size, engine output in World War II was over three times what it was in World War I. It was of course the higher engine pressures permitted by 100-octane gasoline which made possible that marvelous improvement in power.

100-octane aviation gasoline was not merely a development of World War II. The story of how we came to have it begins away back even before World War I. It began when the men in that Dayton laboratory recognized the noisy bugbear of knock as the great shortcoming of gasoline, a shortcoming which, by limiting engine compression, set a barrier to higher power and better efficiency.

When they began to try to do something about it they soon found that whether a fuel knocked or not depended most of all upon the architecture of the hydrocarbon compounds contained in it. The knowledge they were able to gather then was not very extensive, to be sure, but they did find that ring hydrocarbons were better than chain, that alcohols were good, and that olefins were freer from knock than paraffins.

One of the first discoveries which opened the eyes of those early investigators to the important information that knock depended mostly upon the architecture of the fuel molecule was the observation of the circumstance that ethyl ether—the kind used for anaesthesia—was a particularly bad knocker. Normal butyl alcohol, on the contrary, did not knock at all in any of the engines they had then. As Fig. 1 attempts to show, these two compounds, ether and butyl alcohol, have precisely the same ultimate chemical composition, $C_4H_{10}O$, but

the molecular structures of the two compounds are different.

It was out of that early work, which during the war was pursued in cooperation with the U. S. Bureau of Mines, that the first synthetic high-octane aviation gasoline came. That first synthetic aviation gasoline consisted of 70 parts cyclohexane (made by hydrogenating benzene) and 30 parts benzene. By present standards—standards not then in existence, of course—it had an octane number of 75 at lean or cruise mixture ratio and of about 100 at rich or take-off mixture. Those ratings are to be compared with that of the fighting grade aviation gasoline of the time, which was only 50 to 55 octane number, lean or rich.

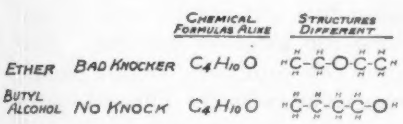



**Fig. 1.—Early Observation of Effect of Structure upon Knock.**

That pioneer program of fuel research was continued during the years following World War I. It yielded, first, the important discovery of the chemical anti-knock agents, of which tetraethyl lead proved to be best. Tetraethyl lead played a vital part in the 100-octane program of World War II. This it did by furnishing a means of boosting up to the level required the mixture of base stock and synthetic blend agent from the 85 octane number which the mixture had of itself alone.

Next that pioneer research proceeded to the investigation in a systematic manner of just how molecular makeup affects hydrocarbons in respect to freedom from knock or power-producing potentiality. And it was out of that further research that the specific knowledge came on which another essential part of the 100-octane program was based, namely, the synthetic blend agent. That knowledge, briefly stated, is as follows:

(*1*) That the worst possible kind of hydrocarbons for giving power are those having the long-chain structure (at the left in Fig. 2)—but that, unfortunately, those are the very kind which are present in petroleum for the most part.

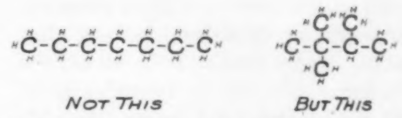



**Fig. 2.—Bad Hydrocarbon Structure and Good from the Viewpoint of Engine Power as Limited by Knock.**

(*2*) That the best hydrocarbons—those with highest power-producing properties—are those which are closely compacted in molecular structure (at the right in Fig. 2).

(*3*) That, furthermore, the anti-knock agent, tetraethyl lead, is much more effective in hydrocarbons of compacted structures than it is in ordinary fuels—in motor gasoline, for instance.

These three important items of knowledge, once they had been obtained through extensive researches in the field, stimulated research on how to apply them in a practical way to produce high-octane aviation fuels. By that time, around 1930, the petroleum industry had become so conscious of the value of research that there were many thousands of technologists in petroleum research laboratories. On this point Robert E. Wilson said in 1928:[3] "Technically trained men are today in almost universal control of refinery processes, and a veritable revolution has been wrought in both design and operation of our refineries." Some of those technologists then began to try to construct by synthetic means hydrocarbons after the compacted architectures which had been found, *on the say-so of the engine itself*, to be so greatly superior to those of the chain-type present naturally in petroleum.

The first process to be used commercially for making such a synthetic hydrocarbon or blend agent was one in which isobutylene was caused to unite with itself forming a dimer, which upon being hydrogenated gave *iso*octane (see Fig. 3). Only the carbon structure of the molecules is shown, the hydrogens having been omitted for sake of simplicity. The isobutylene used in this process was separated from the gases formed in cracking units. The *iso*octane produced is seen to be of the compacted arrangement already mentioned. When pure, *iso*octane is 100-octane number by definition, for it is the reference hydrocarbon which forms the top of the octane number scale.

[3] R. E. Wilson, "Fifteen Years of the Burton Process," *Industrial and Engineering Chemistry*, Vol. 20, p. 1099 (1928).

In 1934 the U. S. Army Air Corps at Wright Field purchased 1000 gal. of 100-octane aviation gasoline. That gasoline was made by mixing *iso*octane, as a synthetic blend agent made by the pioneer synthetic process just mentioned, with a base stock consisting of a special naphtha of about 75-octane number separated from natural gasoline, and then adding a pinch of tetraethyl lead to bring the mixture up to 100-octane.

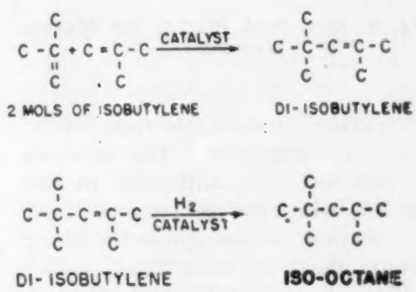



**Fig. 3.—Cold Acid Process for Making *Iso*octane.**

That method of mixing a base stock, a synthetic blend agent, and a little tetraethyl lead became the general means by which 100-octane aviation gasoline has been made ever since. The price paid by the Army for that first 1000 gal. of 100-octane aviation gasoline is said to have been $2.40 per gallon.

The results obtained at Wright Field with 100-octane gasoline in the way of boosted power were so exciting that soon the Army ordered 100,000 gal. more of it. And a few months later, in 1935, they purchased a million gallons. Then by 1937 the Army had established 100-octane gasoline as standard fuel for its combat planes. By that time 100-octane aviation gasoline was being made at the rate of 800 barrels a day, and the price was down to 18 cents a gallon.

In the pioneer process of making *iso*octane as synthetic blend agent isobutylene was the only compound among those present in cracking gases that could be used as raw material. So, as an outcome of further research, a modification of

the process was introduced. This was called the hot acid process—to distinguish it from the pioneer process in which *cold* sulfuric acid was the polymerizing agent used—and it employed as raw material not only isobutylene but also normal (straight-chain) butylene or butene-2, thus doubling the potential yield

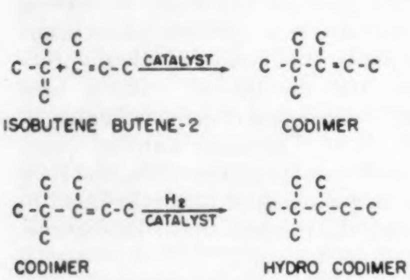



**Fig. 4.—Hot Acid Process for Making *Iso*octane.**

of synthetic obtainable from available raw materials. The product of this second modification of the process, which process has continued to be used, is the synthetic blend agent that is sometimes called hydrocodimer (see Fig. 4). Hydrocodimer has an octane number not of 100 but only of about 95. This did not matter, though, as tetraethyl lead always had to be used anyway to bring up to 100-octane the mixture of base stock and blend agent, which of itself is only about 85-octane, or less.

Next, around the end of 1938, came the third and most important advance in the production of synthetic blend agent for 100-octane aviation gasoline. Here I should like to call attention to the circumstance that by that time Hitler was already in Austria. This third advance in hydrocarbon synthesis is the process called alkylation (see Fig. 5), and it came out of an immense amount of experimentation by many, many people. In the alkylation process olefin hydrocarbons from cracking gases, such as isobutylene and straight-chain butylene, are made to join up with the paraffin hydrocarbon, isobutane, thereby making a synthetic blend agent directly, or without the hydrogenation step. Much greater yields from the available raw materials are obtained by this process too, because it uses more of its components; but the octane number of the product is down a little further still, to 90 to 93. However, as explained before, that did not really matter because octane number could still be brought up to 100 with tetraethyl lead. The alkylation process became by far the most important of the methods used in making synthetic blend agent for aviation gasoline.

Now these synthetic processes by which blend agent is made, as just described, are not conventional petroleum refining by any means, but something altogether new and different in the petroleum industry. They are, in fact, real synthetic chemistry on a huge scale, the production of synthetic blend agents having reached a volume of over 175,000 barrels per day. This is over 7,000,000 gallons a day, or more than 40,000,000 pounds. Thus the design, construction, and operation of the plants for making alkylate and hydrocodimer—and more than 150 of them were in operation

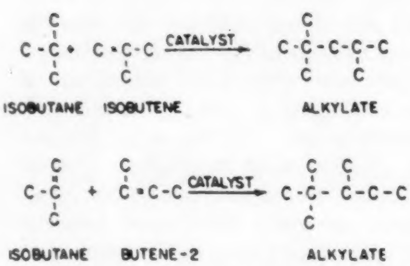



**Fig. 5.—Catalytic Alkylation.**

during the war—was by far the biggest chemical engineering job in history.

There was still another major advance in the production of high-octane aviation gasoline. This improvement related to the base stock—the material with which the synthetic blend agent was mixed. Up to the time of Pearl Harbor and after, most of the base stock used in making 100-octane aviation gasoline had been a straight-run naphtha distilled from selected crude oils. Such a naphtha had an octane number of 73 or so. Thus a relatively large proportion of synthetic blend agent was required to give a mixture that could be brought up to 100-octane number with tetraethyl lead. The proportion of synthetic required then might be as much as 60 per cent, and the volume of 100 octane aviation gasoline that could be made was limited accordingly.

But after Pearl Harbor the catalytic cracking process was drafted into the program. Catalytic cracking had been begun commercially in 1936, after years of prior experimentation, with the Houdry process for making motor fuel. Experience in the interval had shown that, by catalytic cracking, naphthas could be produced which had an octane number not of 73 but of 83, or even higher. And it was found that the use of such a naphtha would cut practically in two the proportion of synthetic blend agent required per barrel of 100-octane, thereby again greatly increasing the potential supply of 100-octane gasoline. So the existing catalytic cracking plants were taken off the manufacture of motor fuel and put to making base stock for aviation gasoline. Also many new catalytic cracking plants, some using radically different methods of operation resulting from still further research, were built.

Thanks to all these results of research, and to a stupendous construction program to put them into effect, the amount of 100-octane aviation gasoline which was being produced at the end of the war was very much larger than any one thought possible at the outset. Production reached the huge total of nearly 600,000 barrels per day. That is more than twice as much as *all* the gasoline being produced in 1918, during World War I, for every purpose: for cars, for trucks, for tanks, for airplanes, both civilian and military (see Fig. 6). Also the

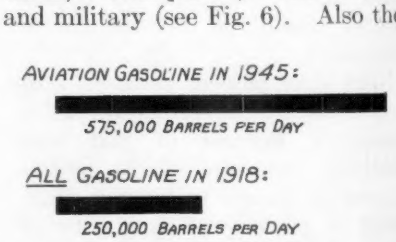



**Fig. 6.—Twice as Much Aviation Gasoline Was Made in 1945 as of *All* Gasoline in 1918.**

price of 100-octane aviation gasoline was down to about 15 cents per gallon. When it is remembered that the aviation gasoline of World War I was only about 50-octane number, and that it cost 25 cents per gallon, or more, this is surely a radical improvement in materials.

### Other Products from Petroleum Research

There are other instances of great improvements in materials within the field of petroleum that have been brought about through research. Two of these are the extreme-pressure lubricants and the heavy duty lubricating oils, the latter having such remarkably high resistances to oxidation at elevated temperatures. Because of that quality of high resistance to oxidation, heavy duty oils made a large contribution to the success of the war just closed, where they were used with great benefit in all Navy diesel engines, as well as in all the engines of the U. S. Ground Forces, both gasoline engines and diesel engines. Heavy duty oils have detergent qualities too, and these had revolutionary effects in keeping engines clean during service.

Another important result of research is the means of making toluene for TNT out of petroleum. Thanks to that development, there was in World War II no shortage of toluene. A number of plants for making toluene out of petroleum were in operation. One of those plants alone is said to have turned out toluene at a rate greater than the total production from every source in World War I.

Among the many new materials which research has shown how to make out of petroleum, the synthetic rubbers should not fail to be mentioned. That was surely one of the most fortunate and revolutionary developments of the war, for without it a war of wheels simply could not have been won. In the merely passing mention that can be made here of even so great a development, I should like to call attention to one thing about the famous Baruch Report of 1942 on The Rubber Situation. This is the quite unusual recognition which that report contained of the efforts of the technologists involved. To do that I need quote only three sentences from the report, as follows:

"Probably the most interesting and satisfying part of our study is the confidence we have acquired in the men from industry who have the plans in hand and who are satisfied they can lick the problem in the given time. Their competence and experience, their resourcefulness and ingenuity are the best guarantees we have that they can do so. We have been much impressed with the fact that this stupendous undertaking is only possible because of the highly developed skill of our technologists."

And it is surely gratifying that events since the date of the Baruch Report have shown that confidence to have been so fully merited.

### Rubber

There have been many outstanding developments in the field of natural rubber, of course. But perhaps none of them greater than the original discovery of vulcanization by Charles Goodyear. That great discovery of Goodyear's converted a useless material, sticky and runny in summer and hard and brittle in winter, into one of the most marvelous and useful materials in all the world. And what a revolution rubber itself has since made for all of us!

Now there is a particular reason why I am mentioning this century-old discovery here, and that is to give opportunity for making reference to a thing which for a long time has been a surprise to me. This is that nothing has ever been done to make a historical shrine out of the New England dwelling in the kitchen of which, after years and years of patient struggle, Charles Goodyear made that great discovery of his so long ago now. That fine old dwelling still stands on Montvale Avenue in the small city of Woburn, Mass. Surely that old house, a present-day picture of which is shown in Fig. 7 is worthy of being preserved in the best way possible. It might be hoped that some of those who read this may help to bring that about.

### Research Yields New Methods of Test

From the viewpoint of our Society, it is interesting and important to mention as well that research yields improvements also in the *testing* of materials. The Test for Brinell Hardness of Metallic Materials (E 10 – 27)[4] and the Tests for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials (E 18 – 42)[5] are surely important supplements to the file test, which was the only one used in the early days of the hardening of steels. So also the methods of testing fuels for knock as now used (D 357 – 45[6] and D 614 – 44 T[7]) are far superior to

[4] 1944 Book of A.S.T.M. Standards, Part I, p. 973.
[5] *Ibid.*, p. 979.
[6] 1945 Supplement to Book of A.S.T.M. Standards, Part III, p. 20.
[7] 1944 Book of A.S.T.M. Standards, Part III, p. 1242.

Photo by T. A. Boyd

**Fig. 7.—The Historic House in Woburn, Mass., in the Kitchen of Which in 1839 Charles Goodyear Discovered How to Vulcanize Rubber.**

the approximations in use before the extensive investigations which have since been conducted in that field. The same applies also to present methods of testing lubricating oils in actual engines by contrast with the purely laboratory methods which used to prevail.

Many new methods of testing resulting from research were developed or applied during the war period just closed. Thus in the field of petroleum there was extensive application of infrared spectroscopy and of the mass spectrograph for the identification of hydrocarbons. In Committee D-2 several new methods were developed, including means for determining olefins, aromatics, paraffins, and naphthenes in aviation gasoline (ES – 45a[8] and ES – 46[9]), and for the determination of inorganic elements in lubricants (D 808 – 44 T,[10] D 810 – 44 T,[11] and D 811 – 44 T[12]). The use of X-rays for detecting flaws (E 15 – 39 T[13]) has recently been extended, and some huge X-ray machines operating at two million volts or more are in use. Magnetic effects are being utilized for detecting flaws also. The methods of magnetic particle testing and inspection of steel castings (A 272 – 44 T[14]) and of heavy forgings (A 275 – 44 T[15]) are effective procedures for revealing defects on the surface or near the surface of such parts. These methods may reveal flaws which in some instances are not detected even by the X-ray. Recently high-frequency sound or supersonic methods have come into extensive use for measuring the thickness of inaccessible parts, and for detecting hidden flaws or discontinuities. An important merit of supersonic methods for finding flaws is that their utility is not limited to regions close to the surface. These methods are most useful for showing up flaws which are deeply embedded, and, as in magnetic testing, they also may find flaws which the X-ray passes over.

Sometimes a testing method is itself an important aid in the development of new things, or it may even be the key to an advance. The End-Quench Test for Hardenability of Steels (A 255 – 42 T[16]), which played such a vital role in the development of the National Emergency steels, is one such method. Without this test there would have been no dependable means short of extended experience in service for developing those steels which, by making such large savings in alloying elements, were of the greatest importance in the war. In the emergency that had to be met then there was of course no time for such extended experience to be obtained. But, fortunately, as was said by Harry W. McQuaid in the Woodside Lecture for 1944,[17] "The real basis of all steel selection and treatment is hardenability, and it is this factor which controls physical properties, internal stresses, and other reactions which are felt during the whole cycle of processing and in service."

To be of use as a guide in making advances, a test method must of course give results which relate to practice. Unfortunately, that is not as true as it might be of every laboratory method of test, and it is in recognition of this condition that the Society has set up an Administrative Committee on Simulated Service Testing.

### Further Materials from Future Research

It goes without saying that many more new materials and new products will come out of research yet to be done. The greatly accelerated tempo of experimentation now in progress will make this doubly certain. There is no intention of attempting to enumerate here what these new materials and products may be. It is not likely that there is enough knowledge in existence today, or enough imagination either, to make such an enumeration possible.

But some of those materials will in all probability be such as to give better solutions of problems which are well known today, for such materials will be actively sought after. A prime one of these needs is surely for a low-cost nonrusting iron or other metal. Such a material is so badly needed, in fact, that one sure way to make a billion dollars would be to invent it. A metal which will be more enduring under the severe conditions of combustion turbines is also so much in demand right now that it seems reasonable to expect that some one will find such a material, or at least an improvement over the materials now available. A glass which is more nearly safe than that which nowadays is called safety glass is another need.

I shall not attempt to write out a list of new materials or improvements in existing materials which it would be advantageous to have. Instead, I shall limit myself to saying that the great improvements in liquid fuels which yielded the 100-octane aviation gasoline, as already described, are of course not to be taken as the end of that road at all. Exploration in that field, which has been consistently pursued during recent years has continued to widen the scope of knowledge of the subject and has added new hydrocarbons to those already known which are capable of extremely high engine outputs.

A considerable part of the search just mentioned has been conducted under a jointly sponsored endeavor called the American Petroleum Institute Hydrocarbon Research Project (now API Project 45). The chairman of the committee which steers this endeavor is Dr. R. F. Marschner, of the Standard Oil Co. of Indiana, he having recently succeeded Dr. D. P. Barnard of the same company, under whose chairmanship the work was initiated some years ago. The results of this endeavor, which represent the most extensive data on the knocking properties of individual hydrocarbons in existence, now constitute the universal "bible" in that field.

A little of what the further possibilities in the hydrocarbon field are may be seen from the behavior of triptane, a hydrocarbon for which our own laboratory has recently developed what appears to be the best method of synthesis yet in existence. Engine tests of triptane as a fuel conducted meanwhile, using the product of our little plant, have shown that, in engines properly adapted to burn it, triptane can give two to three times the power obtain-

[8] 1945 Supplement to Book of A.S.T.M. Standards, Part III, p. 153.
[9] 1944 Book of A.S.T.M. Standards, Part III, p. 1100.
[10] *Ibid.*, p. 1215.
[11] *Ibid.*, p. 1255.
[12] *Ibid.*, p. 1264.
[13] *Ibid.*, Part I, p. 1928.
[14] *Ibid.*, p. 1287.
[15] *Ibid.*, p. 1271.
[16] *Ibid.*, p. 1360.
[17] "Post-War Steel and Its Treatment," *Metal Progress*, Am. Soc. Metals, Vol. 46, No. 5, p. 1067 (1944).

able with *iso*octane or 100-octane gasoline. Or, alternatively, compression ratio may be boosted and the gain with triptane taken not as improved power but as higher fuel economy. Although the possible percentage gain in economy could not be as large as that in power, it would nevertheless be a big one. Of course the full realization of the potentialities of high-output fuels, such as triptane, involves the development of engines particularly adapted to use them.

Just what the effect of all these advances in fuels will be in peace time it is too soon to say. Some think the effect will not be very great because the cost of synthetics is too high. Others think that, on the contrary, the effect of recent developments in fuels will in all probability be large, both in aircraft and in ground vehicles. As for the objection of high cost, one inevitable result of advancing techniques is to bring costs down. For instance, the 100-octane aviation gasoline of World War II cost a great deal less than the low-octane gasoline of World War I. So also the cost of making the 80-octane automobile gasoline being sold just before the war was no higher than that of the 60-octane gasoline of a few years back. It would seem quite reasonable, therefore, to think that gasoline users stand to benefit to a large degree from all these developments. And it is of course a fortunate thing about research that the users of products to which the research applies are the final beneficiaries of it.

# Wartime Materials Developments and the Postwar World[1]

**By J. C. DeHaven[2]**

MANY laymen are now becoming a little bit suspicious of anyone who talks about the wonderful things that are to be his in the postwar world. At least, during the latter part of the war, he has been confronted by magazine advertisements, has read popular articles in the press, and has been blasted by the radio with promises that as soon as the Zilch Co. finished winning the war, their entire facilities for turning out "Super-Stuff" (exact nature restricted by military necessity) would be devoted to making his life a bed of roses in a land of milk and honey. He had really expected that, within a week of V-J day, a helicopter salesman or two would have called on him to sign on the dotted line for spring delivery of a streamlined beauty to be used in commuting between the office roof and that open space in the back yard between the plum tree and the peony bed. But he had not been approached and he felt vaguely disappointed.

Mrs. Average Citizen was not able to find a single one of those lightweight divans that you could lift with one hand and sweep under with the other; and there was not a respectable line formed anywhere to buy nylons, let alone those wonderful stainless steel stockings that were to last a lifetime. When the pictures of the new cars were released, both felt really let down. They had thought at least the de luxe models would have plastic turret tops, and Mr. Average Citizen had predicted a rear-engined, gas turbine model from the Ultra-Six people—of course, he wouldn't buy one for the first year or so, until all of the bugs were worked out.

Engineers and materials men are oftentimes in no better position to evaluate the true status of the wartime developments than individuals without their technical training and experience. The general tendency of the technical man is to minimize the extent of the changes rather than to overemphasize them. This is probably caused by his being so close to the details of his particular field of interest that he has not grasped the real over-all progress that has been made; and in being so involved, by necessity, with his own field, that he has not become familiar with developments in other technologies. Then too, such spectacular developments as radar, the gas turbine, and the atomic bomb have caused many materials improvements to be paled by comparison. We certainly must remember, however, that these devices have been made possible entirely as much by research and improvements in materials and methods as by research in electronics, turbine design, and nuclear physics.

## Gas Turbines

To illustrate this point, the principles of the gas turbine have been known for years. Experimental turbines had been built which, although they would run, were very inefficient, generating just about enough energy to turn their own rotors without much left over for doing useful work. It is true that the improved design of the compressor was an important factor in making the gas turbine practical, but turbines would be very short-lived and inefficient if it were not for the development of special temperature-resistant alloys for turbine buckets and nozzles.

This alloy development program had a head start before the war because temperature-resistant materials were required for turbo-superchargers which are somewhat like gas turbines in operation. However, turbo-superchargers operate at temperatures of 1200 to 1350 F. while gas turbines must operate hotter and over a greater service life to become really efficient. By concentrated research, sponsored and carried out by the Armed Services, by the Office of Scientific Research and Development, and by private industry, alloys were developed which would meet these requirements, so practical gas turbines became possible for ship and aircraft propulsion.

As is the healthy attitude of most scientists, the turbine engineers are not satisfied with the present gas turbines, but are seeking to realize the even greater efficiency theoretically possible with higher compres-

[1] Paper presented at the A.S.T.M. District Meeting in Cleveland, December 4, 1945.
[2] Research Engineer, Battelle Memorial Inst., Columbus, Ohio.

*Courtesy Westinghouse Electric Corp.*

**A Variety of Turbine Blades Produced by the Investment (Lost Wax) Casting Process. In the above group are alloys of 12 per cent chromium, 18-8 molybdenum, stellite, and aluminum.**

sion ratios and higher operating temperatures. The metallurgists are cooperating by conducting fundamental studies of the characteristics of temperature-resistant materials with the view of producing a product that will meet the new demands. Each upward step in operating temperature becomes increasingly difficult for the metallurgist to meet. It is like having the ball on the opponent's twenty-yard line—every additional yard toward the goal becomes tougher because of the more restricted field of action. However, some very encouraging advances are being made which may result in the gas turbine becoming one of the most efficient engines ever known. We may not have gas turbines in automobiles for some years, if ever, but certainly they will appear in increasing numbers in transport aircraft, in ships, and in stationary power plants.

### Casting Techniques

It is an often-neglected fact that improvements in manufacturing control, techniques, and practices have been as equally important, if less spectacular, wartime developments as improvements in materials *per se.* In truth, many advances in quality and dependability of materials have resulted entirely from research on production methods, which permitted a superior product to be fabricated without much change in design or chemistry. Castings in general are an example of this. Very superior magnesium, aluminum, steel, and bronze castings have been made during the war as a result of careful studies of the casting process from the melting of the metal through heat treatment.

An especially interesting casting development of the war years has been that of the precision investment-casting process. The art of this method is old, but the science is very new. Benvenuto Cellini, the famous sixteenth-century Italian artist in metals, used the essential features of the process in making some of the most beautiful metal art work ever produced. The method came to be known through the years as the lost-wax process, not because the knowledge of the process was lost, but because the wax pattern was destroyed in making the mold. Dentists and some manufacturing jewelers were the only people to make much use of the technique before the war. The cast-to-size gold inlay of the modern dentist is certainly a much more humane way of filling a tooth than the treatment our grandfathers were exposed to, in which the dentist beat gold foil into the cleaned cavity with a hammer and chisel.

The war brought a demand for large-scale production of complicated parts of wear- and heat-resistant metals which are extremely difficult to machine or even grind. The lost-wax process was seized upon as being a potential method for producing these parts.

The part to be made is first cast in wax or plastic in a metal mold. The wax patterns are then trimmed and mounted in multiples around a common wax sprue and runners and risers in wax attached. The unit is dipped in a slurry of fine refractory material so as to have a fine surface material next to the metal which is eventually poured into the completed mold. After slow drying, the dipped wax assembly is invested with a fluid refractory mix containing special binders. When the refractory mold has set, it is slowly heated to about 1800 F., during which time the wax or plastic pattern melts and burns out of the mold, leaving a cavity the shape of the desired casting. The molten metal is then forced into the hot mold, either by centrifuging or by gas pressure over the metal in the furnace.

The process sounds simple and straightforward, but a great amount of research has been devoted to the development of suitable waxes, dip coats, and investment materials, so that castings with fine surfaces and as-cast dimensions within plus or minus several thousandths of an inch can be made. At first, a few ounces was the weight limit for precision-investment castings, but as improved techniques were worked out, the weight limit was raised to several pounds. Research now in progress shows promise of permitting castings weighing over a hundred pounds to be made, in the future. Gears, turbine buckets, gun parts, dies, molds, special automobile parts, optical instrument parts, and other products which are difficult to machine, either because of their hardness or intricacy, will be made by this war-developed method.

For many years, piano manufacturers have been interested in the possibility of lightening pianos through the use of aluminum. One of the heavier parts of a piano is the plate upon which the strings are set. This plate had always been made of cast iron, and even in a small spinet piano, weighs around 125 lb. Attempts in the past to

substitute aluminum for cast iron for this part had always resulted in failure because the aluminum plate would "creep" under the tension of the strings, causing them to slack off and the piano to go out of tune.

Using methods originated during the war for developing aluminum aircraft castings for highly stressed applications, satisfactory aluminum piano plates have been produced as permanent mold castings. These plates weigh only 45 lb. and thus result in a 64 per cent saving in weight. A "creep" resistant alloy and special heat-treating process used during the war enabled the metallurgist to meet the requirements for an alloy of sufficient hardness to reduce to a minimum the point of contact between the plate and the strings; an alloy in which string pegs could be mounted and bent to required shapes without deforming the holes into which they are driven; and a design which would distribute the metal so that graduations of thickness in the plate would have a direct relationship to the stress involved.

The latter problem was solved by studying the stress distribution in the plate, under tension of the strings, by using a brittle lacquer. The location and frequency of cracks in the lacquer were compared with known standards and analyzed. Strain gages with electronic indicating equipment, such as was widely used for the design of airframes, was used to complete the study. Thus, these methods, perfected during the war, by research, have permitted a widely used civilian product to be improved in a manner that was previously thought impossible.

### Forming Aluminum Sheet for Aircraft; New Material for Dies

The tremendous demand for aircraft during the war required that techniques for forming aluminum sheet be developed which would lend themselves to mass production. Before the war, so few aircraft were made that many of the complicated aluminum shapes required were virtually beaten out by hand, but these primitive methods could not possibly furnish the parts required for the astronomical number of planes to be built. Then too, stronger aluminum alloys were developed which were harder to form because of their lower ductility. It was highly desirable that these stronger alloys be used for plane construction because they permitted an improved strength-weight ratio and allowed over-all improved performance. It was necessary that these forming operations be flexible enough to allow structural changes to be made quickly, because aircraft design cannot be frozen in wartime. The Germans found this to be true to their sorrow; they had frozen designs to permit greater production of standardized models, and soon found their planes outfought by a smaller number of Allied planes.

Taking all of these factors into account, the materials engineers evolved some unique forming methods which permitted large-scale production, but were capable of being changed over rapidly when modification was required. Research was conducted on the deformation characteristics of the stronger aluminum alloys; on the minimum-bend radii permitted by different forming operations; and on the proper clamping pressures, forming speeds, die designs, and lubricants for deep-drawing operations.

"Kirksite," a proprietary zinc-base alloy containing small amounts of aluminum, copper, and magnesium as alloying elements, was developed in 1940. It has found wide use in the aircraft industry as a material for forming dies where it is used as a substitute for the conventional steel dies. This zinc alloy melts at 717 F. and dies may be made from it as sand or plaster mold castings in a matter of hours instead of the days required to make steel dies. Many dies can be cast to finished shape, so that skilled die makers are not needed.

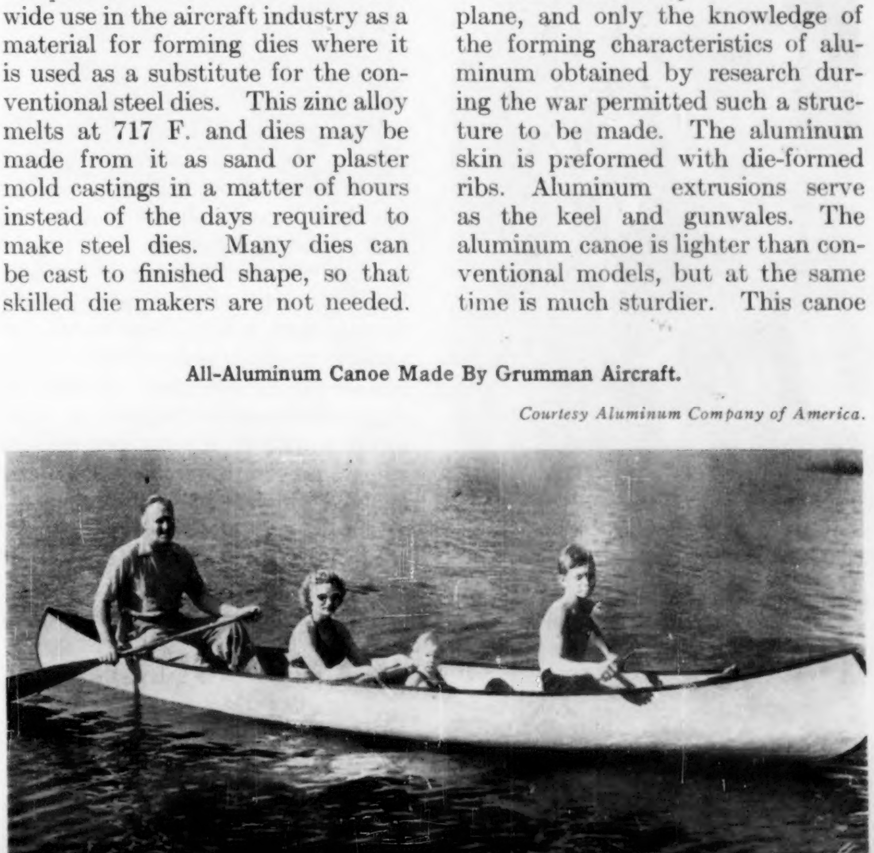
Stretch-forming of large aluminum sheet parts was perfected during the war. In this operation, the sheet is held in a horizontal position by wide clamps at either end. A single die, often made of wood, of the shape of the part desired is mounted on a hydraulic piston midway between the clamps. Motion and force is imparted to the die by the hydraulic piston, causing the die to be pressed against the tightly held sheet and thereby stretching it over the die to the desired shape.

Another technique for using a single die is the so-called Guerin process. The die is mounted in one half of a hydraulic or mechanical press and a thick rubber pad, slightly larger than the over-all dimensions of the die, is mounted in the other half of the press. The aluminum sheet to be formed is placed between the rubber pad and the die. As the press is closed, the rubber forces the aluminum sheet around all of the contours of the die, thus forming the part. The rubber chemists had a hand in making this process successful by developing a synthetic elastomer with the proper resiliency and long life to be practical for this process.

An interesting peacetime application of this know-how in aluminum fabrication has recently appeared in the announcement of one of the eastern aircraft companies of an all-aluminum canoe. This canoe is constructed very much like a plane, and only the knowledge of the forming characteristics of aluminum obtained by research during the war permitted such a structure to be made. The aluminum skin is preformed with die-formed ribs. Aluminum extrusions serve as the keel and gunwales. The aluminum canoe is lighter than conventional models, but at the same time is much sturdier. This canoe

**All-Aluminum Canoe Made By Grumman Aircraft.**

*Courtesy Aluminum Company of America.*



will certainly appeal to outdoor people, but it will undoubtedly have to compete for their favor, not only with the prewar types, but with magnesium and sandwich-construction canoes which will also be light and strong. Whichever his choice, the buyer cannot fail to gain by obtaining a markedly superior product brought about by research.

### Applications of Magnesium Alloys

The production of magnesium during the war increased over fifty-fold from 1939 to 1944. Much of this production was utilized for incendiary bombs; but a sizable amount was employed as an engineering material in the form of castings, forgings, sheet, and extrusions. At first, the entire production of magnesium alloys was reserved for aircraft applications where lower weight paid off so handsomely with increased performance, greater bomb loads, or more armament. As the supply of the metal increased and the great value of airborne armies became apparent, applications of magnesium were made to artillery weapons, small arms, telephone, radio, and radar equipment. The lightness made possible by magnesium in no way impaired the efficiency of this matériel, and besides making it easier to transport by air, permitted it to be handled with less effort on the ground.

*Courtesy Dow Chemical Co.*

**The Much-Talked-About Magnesium Wheelbarrow Weighing Only 30 lb. Compared with the 85-lb. Weight of a Heavy-Duty Steel Product of the Same Size.**

The development of the helium-arc welding process has been an outstanding wartime innovation in magnesium technology. In this welding process, helium gas is flushed past the electric arc to form an inert atmosphere around the molten metal at the weld. The joining of magnesium is easy to accomplish by this method, and the resulting weld is strong. During the war, helium-arc welding was used for assembling many parts for aircraft, ordnance, and communication equipment. It is interesting to note the application of helium-arc welding to the construction of a peacetime all-magnesium wheelbarrow. These wheelbarrows are made of magnesium sheet, extrusions and castings all welded together to form a strong rigid structure. Although the magnesium wheelbarrow will weigh only about 40 per cent as much as a conventional steel product, it will be equally strong, and as the magnesium sheet in the body will be thicker than the steel body sheet, it will be stiffer and less subject to denting.

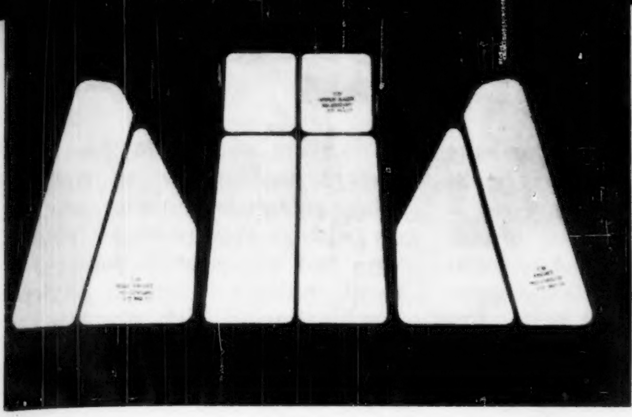
Hundreds of thousands of aircraft landing wheels, from tiny tail wheels 6 in. in diameter to wheels 8 ft. in diameter for super-bombers, have been cast from magnesium alloys. These wheels have absorbed terrific punishment in bearing the weight and withstanding the impact of heavily loaded aircraft in taking off and landing on rough fields. The application of magnesium castings to this rugged service has proved entirely satisfactory, and suggested the use of magnesium wheels for automobiles and trucks to cut down unsprung weight in cars and lower dead weight in trucks, trailers, and buses. After considerable experimenting with design, and based on experience with aircraft wheels, a cast magnesium wheel for automobiles has been evolved which successfully meets all of the requirements. The dependability of the wheels has been proved by prolonged evaluation in test cars. Running 5 miles on the rim caused no damage, and induced blowouts at 60 mph. had no bad effects on the wheel. The fact that the wheel is about one third of the weight of a steel wheel and definitely improves the riding qualities of the car has interested automobile manufacturers.

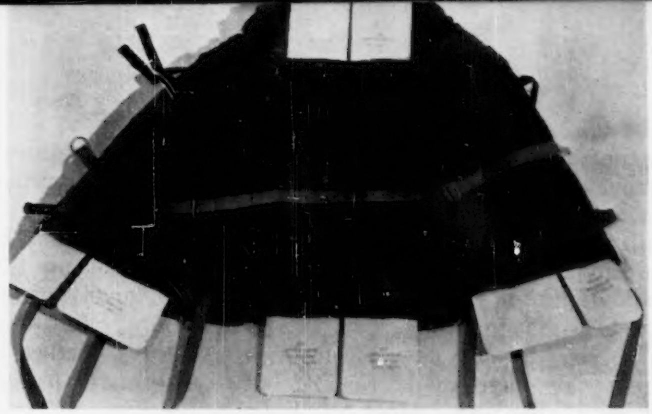
*Courtesy Dow Chemical Co.*

**Aircraft Landing Wheels of All Sizes Were Made from Magnesium Alloys. Two are Illustrated Above.**

### New Uses for Glass

The glass industry is one of the oldest, having come into existence as long as 10,000 years ago. Until the period just preceding the First World War, however, relatively little research was conducted on glass or glass products, and glass was at about the same level of development as during the time of the Phoenicians. Flat window glass was uneven and full of bubbles, and plate glass was made by tedious hand methods which made it very expensive. Large quantities of glass were used for containers which were heavy, friable, and not resistant to rapid temperature changes. Temperature-resistant glasses for laboratory ware were first developed by the Germans and later brought to a higher degree of perfection by American glass companies who were awakening to the potentialities of research applied to their products. In the interval between the wars, the research program on glass began to pay dividends, and an amaz-





The Navy Department has just released interesting information on plastic body armor perfected for use by Navy and Marine Corps assault troops and fliers. Laminated glass-cloth combat jackets tested at Okinawa were ready for the assault on Japan. Originated in the Naval Research Laboratory, experiments were supported by the Navy Bureau of Aeronautics and Army Quartermaster Corps. Shown above, *left*, are the plastic plates, and *right*, as assembled in the jacket. *Below* is the jacket in service. Weighing about 18 lb. the plastic suit compares to the World War I Hadfield steel suits of about 30 lb. but the plastic version is somewhat bulky.

Two Navy officers demonstrated the effectiveness of this new armor. Lt. Comdr. A. P. Webster, U.S.N.R., Washington, D. C., fired a .45-caliber pistol at his friend. Lt. Comdr. E. L. Corey, U.S.N.R., of Charlottesville, Va., who wore the plastic armor. The bullet blunted itself against the plastic and fell harmlessly into the hand of "the victim."

A magazine advertisement in December, 1940, which showed Henry Ford hacking with an ax at a plastic automobile fender, helped initiate the Navy Laboratory's plastic research program. It caught the eye of Rear Admiral Harold G. Bowen, U.S.N., then director of the Naval Research Laboratory and now Chief of the Office of Research and Inventions, who had been following the progress in the development of plastics. He picked up the telephone and called Dr. G. R. Irwin, head of the Laboratory's ballistics section, who immediately launched the research work in his section.

ing assortment of glass products with specialized properties began to make their appearance. Bullet-proof glass; glass that withstands direct flame impingement for cooking; flexible glass; laminated safety glass for automobile windows and windshields; glasses with high resistance to acid and alkaline attack in the form of piping, pumps, and valves for chemical processes; and glass blocks and plate for construction, are but a few of the forms of glass which made their appearance as the result of research. Production methods and machines for making plate glass, containers, tubing, and special shapes, rapidly, and with little skilled labor required, decreased the cost and increased the quality of these products.

Shortly before the recent war, the glass laboratories discovered how to draw glass into very fine filaments of controlled diameter and length, and developed methods for accomplishing this on a production basis, with the result that glass has been introduced into entirely new fields of application. Glass-fiber for liquid and gas filters, electrical and thermal insulation, textiles, and laminates has been brought to a high level of development during the war.

Glass fibers spun into threads and woven into cloth have produced textiles which are flame-proof, rot-proof, vermin-proof, and stronger than any textiles previously woven. The same glass cloth used to line the walls of battle-

*Photographs Courtesy Office of Quartermaster General*

ships may be made into awnings and drapes for your home; products that will not rot or burn and that can be cleaned with a damp cloth.

When layers of glass cloth are impregnated with one of the newer thermosetting synthetic resins and bonded under low pressure, a laminate is formed which has ballistic properties which make it very desirable for body armor for combat troops. The boards developed and used for this purpose were lighter than steel, and in equal weights gave better protection from flying fragments and bullets than Hadfield steel, and did not cause injury by flying into fragments when struck. The tensile strength of the material is over 60,000 psi. with an impact strength over 30 ft-lb., Izod. The specific gravity is very low, being about 1.8. This same type of laminate has been formed into fenders, trunk covers, and wheels for automobiles. The advantages for these uses are lightness, a scratch-resistant surface, and the ability to withstand bumps without denting. This use of glass is indeed far afield from a milk bottle, even one of the newly developed, light-weight, square milk bottles.

### Plastics and Their Uses

The plastics industry occupies a confused position in the public mind. It has been characterized even by high government officials as a "gadget industry." This is not entirely a misconception, since many of the so-called "gadgets" have been, and will continue to be, made from these materials. Nevertheless, this conception tends to misplace emphasis, because this is an industry of much greater scope and capabilities.

In 1941, the production of plastic materials totaled about 500,000,000 lb. The production of many of these has been increased sharply during the war, since these versatile materials were called upon to take the place of many others in the war

economy and to do strange and unusual jobs. The production of vinyl resins, for example, which ably replaced rubber for many uses during the war, has been expanded sixfold during the period since 1941 and is still increasing.

Many totally new plastic raw materials have made their debut during the war. Most of these may be expected to occupy a position of increasing importance in the peacetime economy. The silicone resins, for example, represent a totally new approach to the solution of many old problems in the electric industry. A typical application in this field is found in the new unusually small, high-output motors operating at temperatures above those possible with more orthodox insulation. The allyl resins, polyethylene, melamine resins, vinylidene chloride polymers and copolymers, polyethylene imine, cellulose propionate—these are typical of resin raw materials which were laboratory curiosities at the beginning of hostilities, but which have become commercially important since then.

Many of the specific wartime uses of the various such materials may be expected to continue in the peace time economy. Polyethylene, for example, is an outstanding electrical insulator for high-frequency circuits; it may be expected to achieve considerable use in the radio industry. The vinyl chloride resins, which were used quite successfully as fabric coatings for raincoats and truck seats, may be expected to continue in such outlets, and in related ones such as luggage. The various low-pressure laminates, which were used to outstanding advantage in the aircraft industry, point the way to future developments in construction of automobiles and furniture.

It is expected that the economic situation resulting from the war effort will lead to natural emphasis on certain materials as raw materials. Styrene, for example, which accounts for one fourth by weight of all the GR-S synthetic rubber manufactured in this country, is available for plastic manufacture on a relatively large scale as the government synthetic-rubber program is curtailed. Several styrene copolymers are already in manufacture and the number and type of these may be expected to increase.

In addition to new materials, numerous new techniques have been developed during the national emergency. For example, radio frequency preheating results in as much as 91 per cent decrease in curing time of thermosetting resins, with corresponding reduction in mold and maintenance costs; it leads to increased production, mold life and material saving, and results in greater uniformity of product. Furthermore, better molding with inserts is obtained.

Improved techniques of blowing, calendering, and extrusion have resulted in improved sheet materials, tubing, stripping, filaments, and even highly successful plastic bottles. Expanded plastic "foams" of very low density and low "*k*" factor are available for uses requiring light-weight thermal and acoustic insulation.

Improved design has made a commercial possibility of injection molding machines of 50-oz. capacity or greater. By contrast, the largest size employed in Germany during the war was of 14-oz. capacity.

It is unfortunate that during the war many resin and plastic raw materials, often in the form of scrap, were used for many purposes to which their specific properties did not particularly adapt them. For example, plastic shoe soles of inferior properties have led to a definite antipathy in the public mind toward any plastic shoe material. Yet there are available today several plastic soles whose properties compare favorably with those of leather.

Properly selected and used, the plastics family represents a group of materials, exhibiting a wide range of properties and usefulness for many types of peacetime applications. This field is still in its infancy and it may confidently be anticipated that the relative position of this group in the materials field will be considerably enhanced in the years to come.

### Textile Fibers

The important part played by polyamide fibers, such as nylon, during the war, made them completely unobtainable to civilians. These materials, however, are just as widely applicable to civilian uses and will soon be found in a great variety of forms. Nylon's combination of high strength and resiliency is important in its utilization in glider tow ropes which made it possible for these troop and cargo-carrying craft to be lifted off the ground by planes much as if they were mail sacks. A comparison of a nylon rope and a sisal one, of similar strength, shows the circumference of the former to be only 65 per cent of the latter. Where the sisal, however, has no elongation, the one made of nylon could be extended 67 per cent. The difference in weight was similarly striking.

The attack at Pearl Harbor left us without an adequate supply of natural silk for parachutes. Silk had about the right combination of properties to make a good 'chute. In searching for a substitute cloth, nylon was chosen as having about the best chance to succeed. After a tremendous amount of engineering investigation, carried out under the pressure to succeed before the supply of silk was exhausted, a nylon parachute and harness were designed which have proved to be far better than any previously made from natural silk.

Although textiles are not generally considered to be engineering materials, a nylon parachute is as thoroughly an engineered structure as any that has ever been built. The cloth must resist damage from folds, as the 'chute remains packed for long periods, and the surface friction of one fold on another must be low so that opening is not retarded. Of course, the permeability of the cloth has an effect on the rate of descent, and must be controlled in manufacture within narrow limits. Besides these requirements, the parachute cloth and cords must have uniform and low variations in properties and dimensions with temperature and humidity, and must have high shock and tear resistance. All of these features are checked many times on cloth and cord samples, and on completed 'chutes.

The harness tape is so designed as

to be a self-contained shock absorber; not by including springs or rubber in the tape or attachments, but through the design of the material itself, being really two fabrics woven together. Upon receiving a shock of a certain lower intensity, the one fabric fails, allowing the other fabric to uncoil and elongate, thus reducing the impact on the individual in the harness. The second fabric, when extended, will withstand any further shock which could conceivably occur.

Besides the application to parachutes and glider tow ropes, nylon found application in many other important fields, namely, as tropical-resistant tents, fishing lines, nets, screens, and as cord for huge bomber and heavy-duty truck tires. It is no wonder that nylon stockings disappeared from the stores—they had really gone to war.

High-tenacity rayon will continue to find a very substantial market in truck tires and generally in fabrics which are to be subjected to unusually high stresses.

### Synthetic Rubber

The story of the American synthetic rubber industry and its wartime growth has been adequately told before and needs no repetition here. It should be noted, however, that the emergency created by the sudden shortage of this vital raw material was many times more critical than suspected by the general public. The rapid and satisfactory solution of this gigantic problem represented one of the all-time triumphs of the American chemical industry.

Production for 1946 was estimated before V-J Day at 1,200,000 long tons. This has now been reduced to 655,000 tons, of which 84 per cent will be GR-S, the all-purpose variety intended largely for tires. It is anticipated that at least 200,000 tons of natural rubber will aid in supplying next year's demand of 1,000,000 tons.

The future of this type of synthetic rubber is both an economic and a political question. The price of crude rubber delivered in New York varied between the two World Wars from a low of slightly under 3 cents a pound to a high of $1.05. It has been estimated that 12 cents was probably the lowest price which would still provide a fair profit. The actual cost of GR-S is a subject of some dispute, depending upon the book-keeping methods employed. It seems reasonably certain that the product derived from grain alcohol as a source material for butadiene is more expensive than natural rubber, whereas that derived from petroleum may be competitive with the natural product. In any event, it must be borne in mind that costs must be compared on the basis of performance.

Several special synthetic rubbers have been used both before and during the war. It is expected that many of these uses will continue and that new ones will develop for these and other special polymers which may be evolved. Butyl rubber has outstanding gas-proofness and is preferred for inner tubes. Thiokol, Neoprene, and the various American analogues of Buna N find usage where resistance to solvents, oils, and chemicals is important. The recently developed silicone rubber is outstanding in resistance to high temperature, while at the same time maintaining its flexibility at low ones.

At the present time, GR-S is generally regarded as inferior to natural rubber for tires, because of greater heat build-up and greater processing difficulties. It is entirely possible that a modified GR-S, or some new polymer, may completely supplant the natural product for such usage. Recent developments in tire design have indicated that the product must definitely be designed for the raw material.

In addition to supplying a considerable pent-up demand in the passenger and truck-tire field, the rubber industry looks to other fields of application in the next few years. Foamed latex sponge is receiving enthusiastic acceptance in upholstery, and the potential market in furniture, automobiles, and mattresses is enormous. The much-publicized rubber spring for vehicles has been the subject of a large development program and is probably near commercial practicality. Combinations of rubber with various plastic materials for adhesives and coatings is a rapidly growing application. The utilization of chemical derivatives of rubber may be expected to increase in the fields of plastics, protective coatings, and packaging.

The use of new techniques in rubber, such as electronic heating, injection molding, and automatic operations, such as tire building, may be expected to decrease costs, improve quality and performance, and lead to greater utilization of this versatile material.

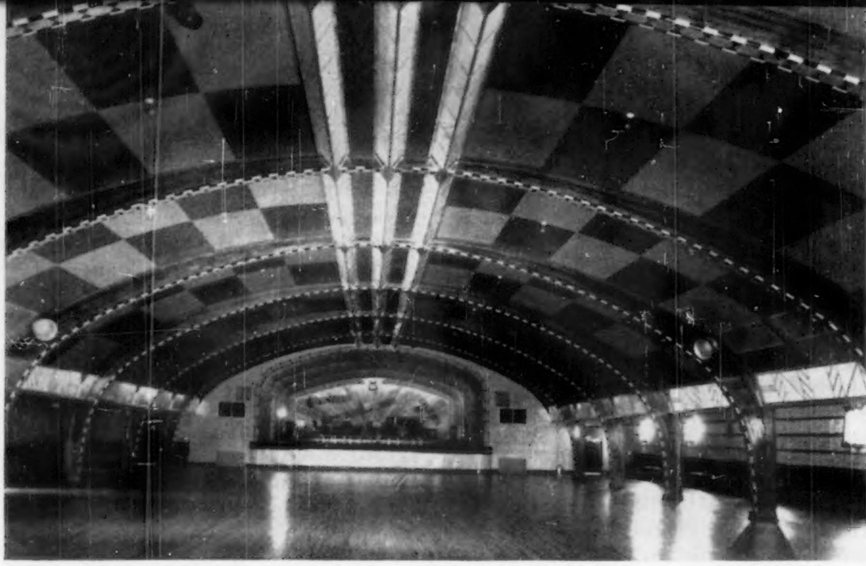
### Wood

Although reports are somewhat conflicting, it appears that the nation's resources of most readily available lumber are declining. It was estimated early in the war that about 25,000 board feet would be required for each member of the military forces. It should be kept in mind, however, that the war-induced drain on lumber resources is no greater than that in a building-boom year such as one in which 700,000 new homes were built. With little opportunity for full-scale continued reforestation during the last five years, it is fortunate that such advances have been made in upgrading wood products, preserving wood against mold and rot, and developing replacements from more plentiful raw materials.

Impregnation of wood with synthetic resins has increased strength, moisture resistance and dimensional stability without an undue rise in density. One such process has been said to be capable of making hardwood from soft woods. The lives of railroad ties could be prolonged by heavier creosote treatment were it not that physical failure in use is the deciding factor. Resin impregnation may be one way of removing this limitation.

Increasing the life of lumber by new preservative means will not only extend our supplies, but will make it possible for wood to be used in applications where it has not heretofore been entirely suitable. Even now, the rather frequently changed location of secondary highways often indicates the installation of timber bridges rather than those of steel or concrete.

Engineering improvements already available will extend the



**Laminated Wood Arch Construction Provides Attractive Building with Large Unobstructed Floor Areas.**

usefulness of lumber. Comparatively small metal connectors not only increase the strength of timber joints, but reduce the number of weak points introduced by an excessive number of bolt-holes. An unusual wartime demand for large timbers, particularly for ships' keels, accelerated the commercial application of a process for building up such large sections from a number of pieces with the aid of waterproof synthetic-resin glues. These "synthesized" timbers may not only be formed either straight or arched, but also may be of variable cross-section according to the stresses involved.

For special applications, lumber replacements are becoming of great importance. In the construction of frame dwellings, much of the sheathing currently used is gypsum board, fiber board, or a composite material. Some, or all, of these products are also rapidly entering the fields of wood lath, roof decks, and even weatherproof siding.

### Spears into Pruning Hooks

Briefly, it may be said that the value of organic materials lies to a considerable extent in their amenability to custom construction. If we want a rubber replacement, a long-life seat covering material, or a high-frequency communications insulator, excellent materials can be found in the forms of GR-S, vinylidene-type resin, and polyethylene. In effect, we need only state the specifications and a product can be found or can be developed.

Many more examples of the application of developments, which have been made during the war, to peacetime uses could be presented; however, they would but reinforce the evidence that wartime research will have a tremendous influence on our future lives. In many, if not most instances, the effects will not be dramatically apparent, but will subtly better our individual standards of living and increase our national wealth. It is most unfortunate that war was the reason for spurring our research efforts. A more benevolent incentive, if such could be conceived that would create the same drive, with an equal research effort, would have permitted us to realize far more benefits from our developmental work. As it is, the terrific wastes of war must be subtracted from the advantages gained in our individual and national lives by the knowledge derived through wartime research.

### Science and Technology—a Vital National Resource

Most people believe that our national resources consist entirely of the physical appurtenances of the country—the mineral deposits, water power, farm lands, and forests. It can be said that the most important national resource of this or any nation is a state of mind, a spiritual rather than a physical deposit. It is the inquisitive nature of the scientific investigator, using the tools and methods that he has devised, which allows even the most abundant of naturally occurring resources to become national and individual wealth. A nation can have a copious supply of ores, fertile soil, and streams, yet remain in poverty, if widespread, technical studies are not continually being carried on to change these natural phenomena of low value to products of increasing usefulness to mankind. The tendency in such a nation is to "mine" the farms and forests and leave the properly available resources relatively untouched. On the other hand, a people who employ the scientific methods of research to the fullest extent could probably become a wealthy nation and enjoy a high standard of living if their only resources were sea water, coal, and sand.

Materials which are used in a form similar to their naturally occurring state, deplete the pool of natural resources, contribute to a smaller degree to national and individual wealth, are vulnerable to replacement by other materials, and tend to be stable or decline in use through the years; while materials which are highly modified from their natural state through research, tend to conserve our resources, increase the standard of living, and grow in application.

For example, composite boards for construction may be made from timber wastes, rock wool, straw, or glass fiber, bonded with plentiful cement, plaster or resins, and used to extend our natural lumber supply. Veneer wood, bonded to composition board, laminates, or metal, allows us to have the attractive wood grain for decorative effects but conserves our high-grade wood. Research has shown us how to recover magnesium from brines and even from the sea. Thus, the sea becomes one of our valuable mineral resources.

Although the impact of wartime developments in materials will not be so obvious to the average person as he may have expected or hoped, the value of the research will nevertheless be realized, as it always is, in gradually increased comfort, a higher standard of living, and an insurance of abundant national wealth.

*Acknowledgment:*

Grateful acknowledgment is extended to F. C. Croxton and L. E. Cheyney, of the Battelle staff, for their assistance with the preparation of sections of this paper.

# The Effect of High Humidity and Fungi on the Insulation Resistance of Plastics


By John Leutritz, Jr.,[1] and David B. Herrmann[1]



Synopsis

The decrease in insulation resistance of methyl methacrylate, glass bonded mica, glass mat laminate phenolic, phenol fabric, phenol fiber, and wood flour filled phenol plastic is determined during prolonged exposure of the plastics to fungi and 97 per cent relative humidity at 25 C. The same plastics with fungi present also are exposed to 87, 76, and 52 per cent relative humidity to study their recovery, and then reexposed to 97 per cent relative humidity. Samples with cleaned surfaces and with varnished surfaces are dried and then exposed to fungi and high humidity. The insulation resistance of a fungus network on methyl methacrylate is determined at 87, 76, and 52 per cent relative humidity.

Fungus growth occurs on all the test specimens except those with cleaned or varnished surfaces. The decrease in insulation resistance is retarded by the varnish. The degradation is due entirely to moisture. The rate of recovery is dependent on the composition and structure of the materials. None of the plastics is permanently affected by exposure to fungi and high humidity. Cleaning of surfaces and removal of moisture restore the insulation resistance to its original high value in every case. Water adsorption and absorption, not fungi, are the critical factors in the deterioration of the insulation resistance of these plastics.


Failure of electronic, communication, and other electrical equipment under tropical conditions of service has focused attention recently on surface contamination of insulating materials by fungi (**8, 12, 14, 18, 23, 24, 25, 27**).[2] The Japanese were working on this problem at least as early as 1934, no doubt as part of the preparation for their aggressions in the South Pacific and Southeast Asia (**21**).

Insulation resistance is known to be affected adversely by water absorption and adsorption, films of condensed water, water-absorbing dust, and other surface contaminants which retain water. In this last category are fungal growths, which, like most living cells, are composed largely of water. However, although experiments which show the effect of high humidity on the electrical characteristics of insulating materials are numerous (**1, 2, 3, 4, 5, 6, 7, 9, 11, 15, 16, 17, 19, 20, 22, 28, 29, 30**), experiments which show the effect of fungi appear to be nonexistent (**31**). One of the chief reasons for this lack of experimental work is that differentiation between moisture and fungus effects is very difficult. In the experiments described in this article, special attention was given to the conditions of test in an attempt to separate the two.

Fungi need moisture for germination of the spores (seeds) and for their metabolic needs. Maximum growth is brought about by high humidity conditions, temperatures between 25 and 32 C., and sufficient food. Conditions which result in high water absorption by insulating materials and condensed surface water favor growth of fungi. However, insulation resistance measurements made on materials upon which water is condensed show practically no differentiation because the electrical leakage of surface water films is common to all. Therefore, to eliminate condensation and still promote growth of fungi the relative humidity of 97 per cent was used.

The materials tested were plastics of the following types:

1. Unfilled—methyl methacrylate.
2. Three cellulose-filled—phenol fiber, phenol fabric, and wood flour filled phenol plastic.
3. Two inorganic filled—glass-bonded mica and glass mat laminate phenolic.

These were divided into two experimental groups, the first including all the types mentioned above, and the second only methyl methacrylate samples. Since the experiments were begun two years ago and the results pertain only to a single representative of each type of material, it is not intended that they be taken as characteristic of materials produced by the most recent methods.

## Preparation of Test Specimens

For the first experimental group rectangular strips similar in form to those actually used in equipment were cut from stock plastic to a width of $1^1/_4$ in. and a length of 4 in. and were drilled for the insertion of seven small metal eyelets $^1/_4$ in. apart along each side. These eyelets, functioning as electrodes, were strapped alternately so that the leakage path would be between adjacent electrodes and from each electrode to all others at different potential. The strips were wired into a large glass-covered wax-sealed glass jar containing a saturated aqueous solution of potassium sulfate and were supported by attaching one set of electrodes from each test specimen to a common ground and the other set to a lead passing through the mineral wax seal of the jar (Fig. 1). The insulation resistance of the wax between adjacent leads was greater than 20,000,000 megohms at 400 v. throughout the test.

The second experimental group comprised four similar methyl methacrylate strips, each $2^1/_2$ in. long and 1 in. wide, fitted with eyelets $^1/_4$ in. from each end and 2 in. apart. A small piece of friction tape $^3/_8$ in. wide was placed around two of the specimens midway between the electrodes. On the remaining two specimens a shallow $^1/_{16}$-in. groove was cut. Before attaching the friction tape and after cutting the grooves the surfaces of the specimens

NOTE.—DISCUSSION OF THIS REPORT IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

[1] Members of the Technical Staff, Bell Telephone Laboratories, Murray Hill, N. J.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

Fig. 1.—Measurement of Insulation Resistance of Various Plastics at 97 Per Cent Relative Humidity (over Saturated Potassium Sulfate Solution) and 25 C.

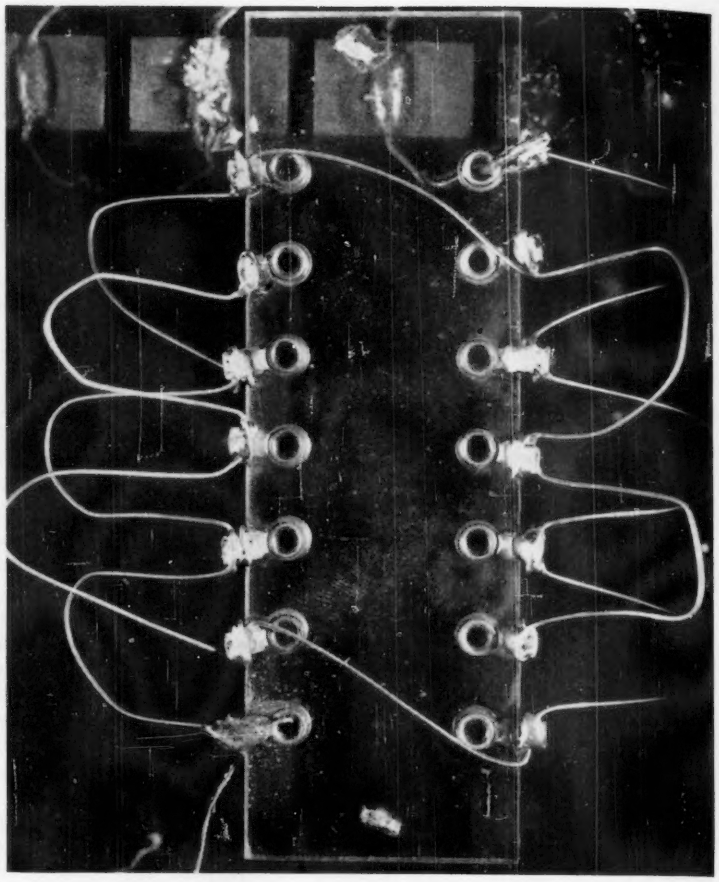


Fig. 2.—Methyl Methacrylate Sample from Stock Showing Inoculation and Surface Contaminations (Fingerprints, Dust, etc.), After 2-Day Exposure at 97 Per Cent Relative Humidity and 25 C.

were cleaned with ethyl alcohol and dried. This difference in surface treatment is a significant part of the experiments. The samples were handled carefully with gloves to prevent surface contamination and each electrode on an individual specimen was attached to a separate lead passing through the seal of a jar similar to that used for the first group of samples.

### Inoculation

After wiring the first group of specimens into the humidifier each was inoculated with an inoculum cut from a pure agar culture of the fungus *Poria incrassata* (Fig. 2). This proved to be unnecessary as the fortuitous spores or seeds which are universally present soon germinated and overcame the original fungus. The friction tape on two specimens in the second experimental group also needed no further inoculation with fungi but in each groove of the remaining two specimens a drop of spore-inoculated agar was placed.

### Measurement Procedure

Measurements of direct current resistance, surface and volume combined, were made periodically with a high-sensitivity galvanometer. This resistance, sometimes designated total resistance, is referred to in this article as insulation resistance, which is the term used by the A.S.T.M.[3] At high humidity insulation resistance is almost entirely surface resistance, at low humidity almost entirely volume resistance. The proportionality is determined not only by humidity but also by properties of the material, such as wettability, porosity, water adsorption and absorption, surface and internal structure, chemical composition, and heterogeneity. Surface leakage is predominant at high humidity for most electrical insulating materials. The galvanometer deflection was read at the end of a 1-min. application of 100 v. Voltage was applied to the specimens only during measurement. The resistance for each specimen first was determined at room conditions with a megohmmeter before the test strips were wired into the humidifier. The temperature was maintained at $25 \pm 1$ C. for 58 and 21 days, respectively, for the two experiments, and then, to insure additional fungus growth, was dropped to 15 C. and held for $2^1/_2$ and $1^1/_2$ hr., respectively, to effect condensation of water. Except for this short period, the relative humidity was maintained with saturated potassium sulfate solution at 97 per cent for 31 weeks and then to study the duration and nature of the recovery cycle for the different plastic types, saturated aqueous solutions of sodium potassium tartrate, sodium chloride, and sodium dichromate were used to give relative humidities of 87, 76, and 52 per cent, respectively. Finally the humidity was again raised to 97 per cent. No corrosion was apparent on the electrodes after the long periods of test, so this complicating factor did not have to be considered in interpreting the results.

[3] A.S.T.M. Methods of Test for Insulation Resistance of Electrical Insulating Materials (D 257–45), 1945 Supplement to Book of A.S.T.M. Standards, Part III, p. 57.

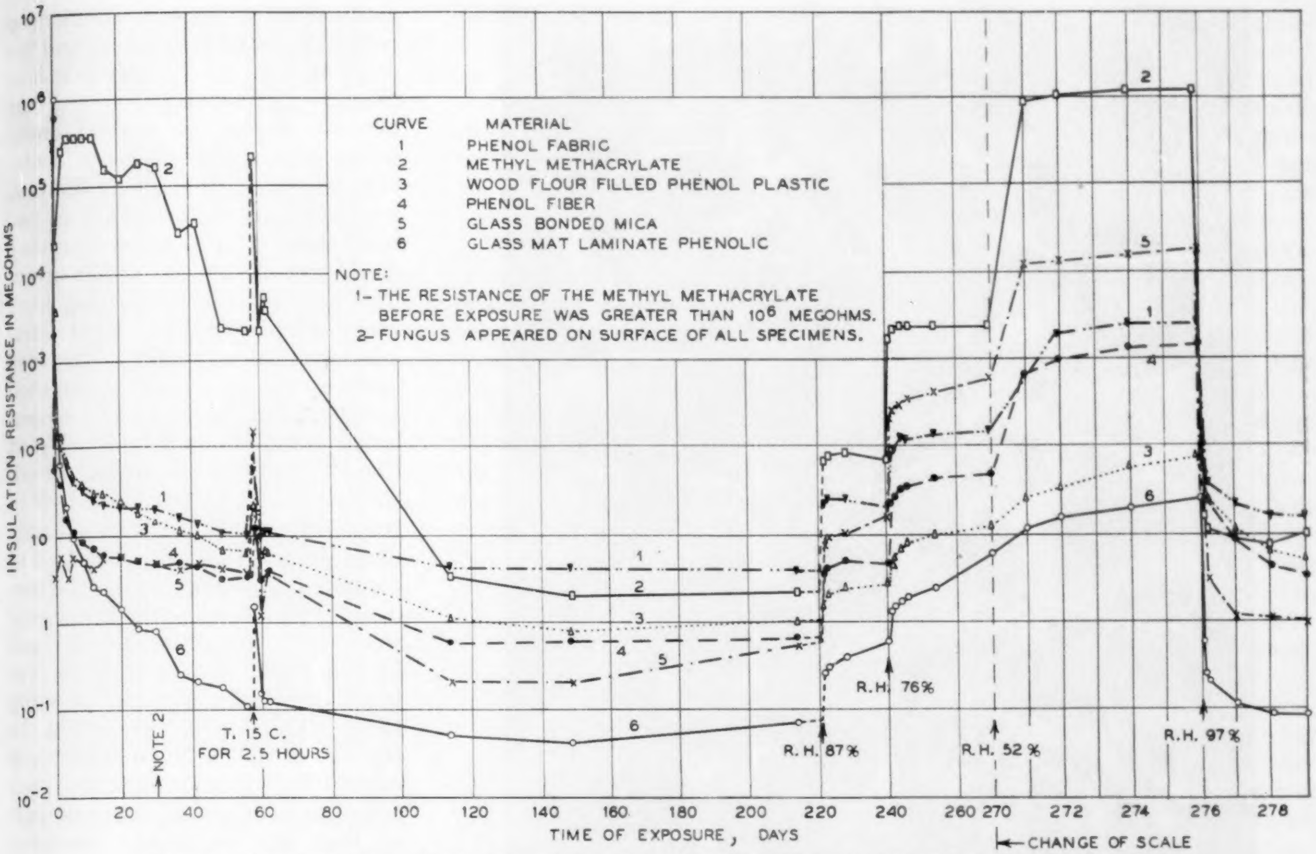



**Fig. 3.—Effect of High Humidity and Fungi on the Insulation Resistance of Various Plastics.**
Temperature 25 C., relative humidity 97 per cent; except where noted otherwise.

### Results of Exposure to High Humidity and Fungi

The data for the first experimental group are given in Fig. 3. Initially at room conditions the methyl methacrylate, the glass-bonded mica, and the glass mat laminate phenolic had an insulation resistance of 1,000,000 megohms or more, the phenol fabric and fiber 300,000 and 600,000 megohms, respectively, and the wood flour filled phenol plastic 3500 megohms. When exposed to 97 per cent relative humidity at 25 C. the insulation resistance dropped below 1000 megohms in $1^1/_2$ hr. for all the samples except the methyl methacrylate. The glass-bonded mica showed the most rapid lowering and then remained practically constant for the first 58 days. Phenol fiber was similar to the glass-bonded mica but lowering to the same value as the mica, 5.9 megohms, required 15 days. The insulation resistance of the glass mat laminate phenolic fell to the level of the mica within 9 days and to less than 1 megohm after 25 days. Wood flour filled phenol plastic and phenol fabric behaved alike. There was a gradual downward trend for 58 days, at the end of which time the wood flour filled phenol plastic measured 6.4 megohms, the phenol fabric 10 megohms.

Methyl methacrylate had the highest order of insulation resistance for the first 58 days of the test. The initial drop in resistance probably was due to slight condensation on the sample. After recovery from the effects of this initial condensation, the insulation resistance remained fairly constant until after the twelfth day, when a break occurred. This effect lasted about 15 days. Two other drops in resistance are recorded during the first 58 days, one between 30 and 37 days and the other between 42 and 49 days. Since the breaks in the insulation resistance readings were very marked and seemed to be correlated to some extent with the growth of fungi on the surface of the specimen (Fig. 4), further experiments with methyl methacrylate samples were indicated.

The sudden rise in insulation resistance noted in Fig. 3 was a result of lowering the temperature to 15 C. The condensation of water which took place evidently was limited to the sides of the glass jar and the probability exists, because of the comparative isolation of the samples inside the jar, that the humidity directly over them was low, thus causing an increase in insulation resistance. It is important, however, to note that recovery was very rapid, especially on the methyl methacrylate sample, despite the presence of fungi (Fig. 4) on the surface. Recovery again was noted each time when the relative humidity was lowered to 87, 76, and 52 per cent. At 52 per cent relative humidity the methyl methacrylate specimen exhibited complete recovery but it was decided to test the effect of a fungus network on a plastic by raising the humidity to 97 per cent. An immediate drop in insulation resistance within 1 hr. occurred, in contrast to a decrease of the same magnitude which previously required 112 days.

Before discussing the results of this experiment and drawing conclusions, the data for the second experi-

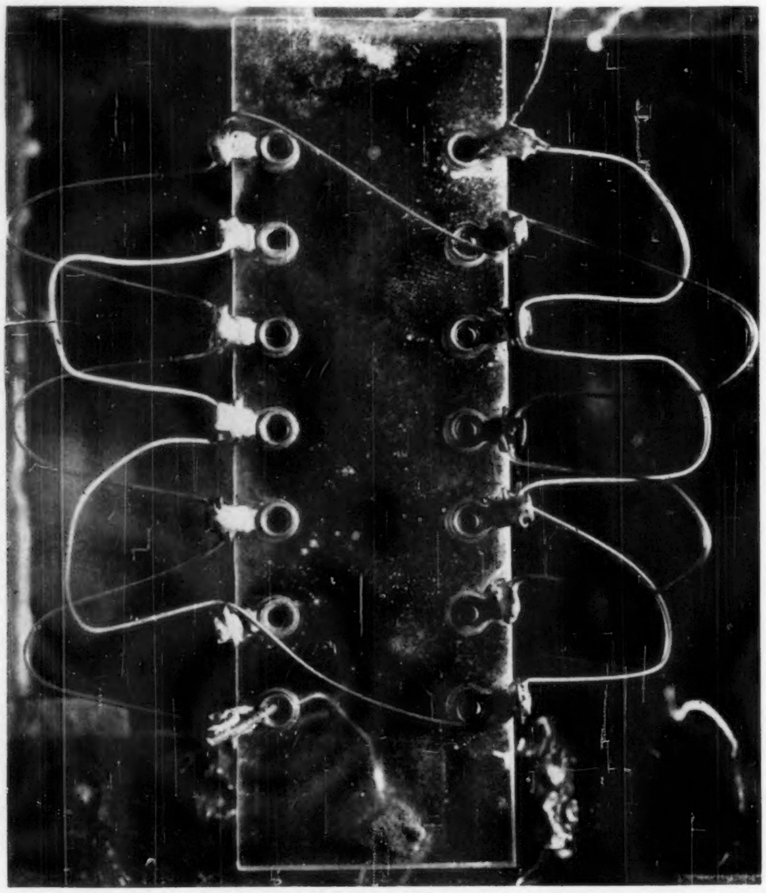


**Fig. 4—Growth of Fungi on Contaminated Methyl Methacrylate Sample After 112-Day Exposure at 97 Per Cent Relative Humidity and 25 C.**

group after 19 days showed a drop to less than 30,000 megohms and the other three to about 150 megohms (Fig. 5). It had been expected that the samples in the second group would be at a higher level of insulation resistance throughout the test, not only because their surfaces had been cleaned but also because they had fewer electrodes farther apart. This anomalous behavior may have been due to a relatively rapid initial adsorption of water on the cleaned surfaces in an evenly distributed very thin film which caused the insulation resistance to drop quickly at the start of the exposure period. The resistance values leveled off in the neighborhood of 100 to 300 megohms probably because of a lack of contaminating material on the surface of the plastic. Such material would absorb additional water and facilitate the building up of the film to greater thickness, hence lowering the insulation resistance further. In the case of the methyl methacrylate of the first group, however, such contaminating material was present so that the insulation resistance continued to decrease to the low value of only 2 megohms.

mental group should be examined. Since the methyl methacrylate sample was the only specimen which showed a significant measurable decrease of insulation resistance as the fungi spread over the surface, the second experiment was begun with only clean specimens. The data in Fig. 5 show an average drop in insulation resistance from 1,000,000 to 160 megohms for three of the four samples within 5 days. The fourth sample was higher throughout the test but after 80 days was in the order of magnitude noted for the others. This latter sample showed a black fungus which differed from the fungi observed on the other specimens (Fig. 6).

All four methyl methacrylate samples of the second experimental group showed a considerably steeper initial decrease in insulation resistance than the methyl methacrylate sample in the first group. The latter, after 20-day exposure to 97 per cent relative humidity, still had a resistance of over 100,000 megohms (Fig. 3), whereas one of the second

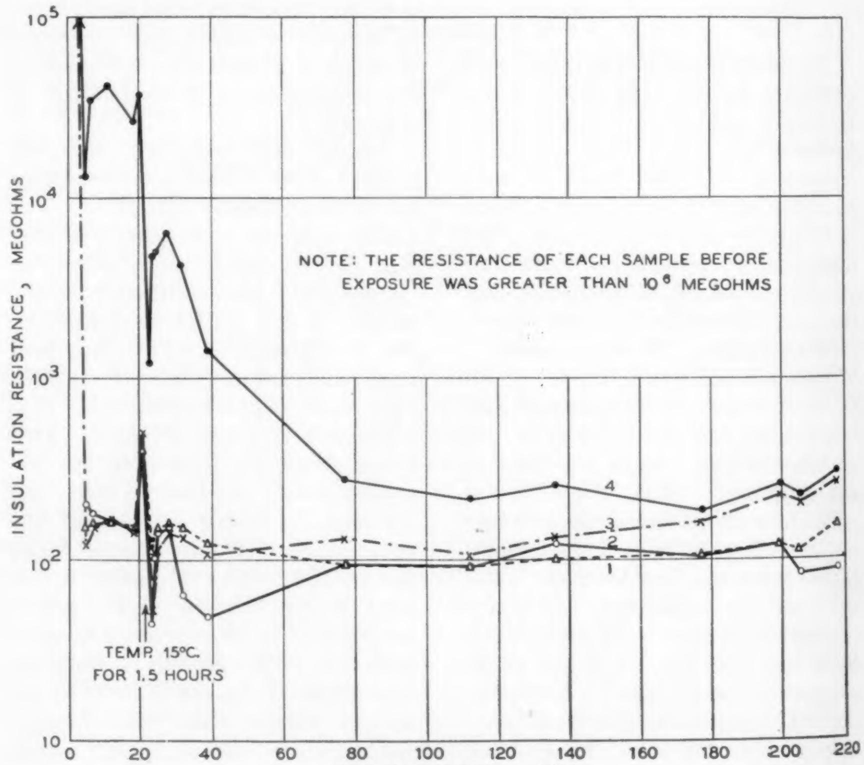



**Fig. 5.—Effect of High Humidity and Fungi on the Insulation Resistance of Four Samples of Methyl Methacrylate.**

Temperature 25 C. except where noted otherwise; relative humidity 97 per cent.

**Fig. 6.—Black Fungus on Methyl Methacrylate Agar Sample. Note failure of fungus to spread across cleaned surface.**

Examination of fungus growth on the specimens in both experiments disclosed that fungi had spread over the surfaces of all the stock materials, but on the clean methyl methacrylate surfaces were restricted to a very narrow zone near the edges of the original inoculum (Fig. 7). The growth over the methyl methacrylate sample in the first experimental group provided the only instance where the effect of fungi on the insulation resistance could be ascertained with any degree of assurance. Microscopic examination revealed a network of fungus filaments on the surface of this sample. The data in Fig. 3 indicate that the insulation resistance of the fungus network is in the order of 70, 2400, and 1,000,000 megohms at 87, 76, and 52 per cent relative humidity, respectively, since the insulation resistance of the methyl methacrylate itself is of a much higher order at these relative humidities. It is believed that this is the first time such a measurement of resistance directly attributable to fungi has been made. The drop in insulation resistance for the other stock materials was so rapid and of such a magnitude due to moisture alone that any further lowering by fungi could not be detected. The failure of the fungus to spread across the clean methyl methacrylate is reflected in the relative constancy of the insulation resistance once equilibrium was established.

When fungi and the water-condensing condition of 100 per cent relative humidity are both present the measurement of insulation resistance does not permit separation of the effects of water and fungi. Comparison of measurements at 97 per cent and 100 per cent relative humidity with fungi present in both cases made on the same materials (Fig. 8.) shows that the electrical leakage of water films at 100 per cent relative humidity also prevents differentiation between materials.

### Results of Drying and Reexposure to High Humidity

The insulation-resistance recovery of the materials of the first experimental group as a result of drying also was determined. After the test at 97 per cent relative humidity following the recovery cycle at low humidities, the six samples were removed from the test jar and scrubbed and rinsed with distilled water to remove fungi and surface debris. For preliminary drying they were placed in a desiccator over phosphoric anhydride for 6 days plus 4 days in the laboratory at 25 C. at or less than 40 per cent relative humidity.

The insulation resistance of the wood flour filled phenol plastic then was 1400 megohms, compared to an original insulation resistance of 3500 and an equilibrium insulation resistance at 97 per cent relative humidity of 1 megohm. The resistance of the phenol fiber was 79,000 megohms, its original resistance 600,000, its lowest resistance at 97 per cent relative humidity less than 1 megohm. The phenol fabric, with a resistance of 200,000 megohms, came within two thirds of its original level of 300,000 after having been down to 4 megohms at 97 per cent relative humidity. The methyl methacrylate was found to have a resistance of over 5,000,000 megohms compared to an original resistance of over 1,000,000 and an equilibrium resistance at 97 per cent relative humidity of 2 megohms. The glass-bonded mica showed a resistance of 390,000 megohms, roughly one third of its original resistance of 1,000,000 and many orders higher than its resistance of 0.2 megohm at 97 per cent relative humidity. The glass mat laminate phenolic, however, showed poor recovery in comparison with the other materials since its insulation resistance after drying was only 8 megohms, while originally it was 1,000,000, and at 97 per cent relative humidity 0.05 megohm.

All the samples but the methyl methacrylate were dried for 3 more days over phosphoric anhydride, at the end of which time the wood flour filled phenol plastic resistance was 86,000 megohms, the phenol fiber and phenol fabric over 5,000,000, the glass-bonded mica 1,400,000, and the glass mat laminate phenolic 20.

The surface of the glass mat laminate phenolic was tested for acidity and alkalinity because its resistance still was very low. Neither was found. Nevertheless, the sample was washed thoroughly with distilled water, ethyl alcohol, and ethyl ether, consecutively, to see whether

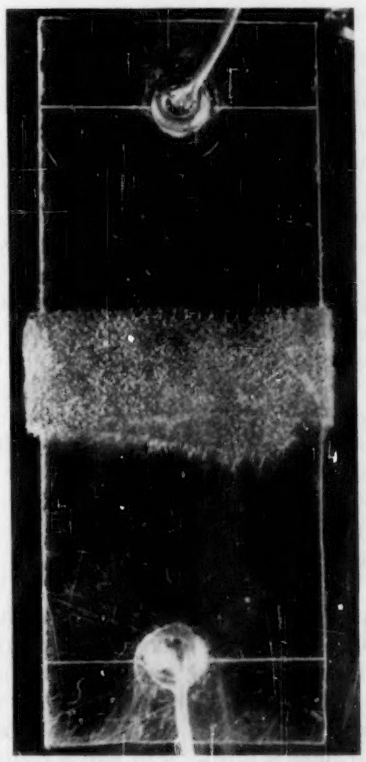


**Fig. 7.—Fungi on Methyl Methacrylate Friction Tape Sample—No Growth on the Plastic in the Absence of Fungus Nutrients.**

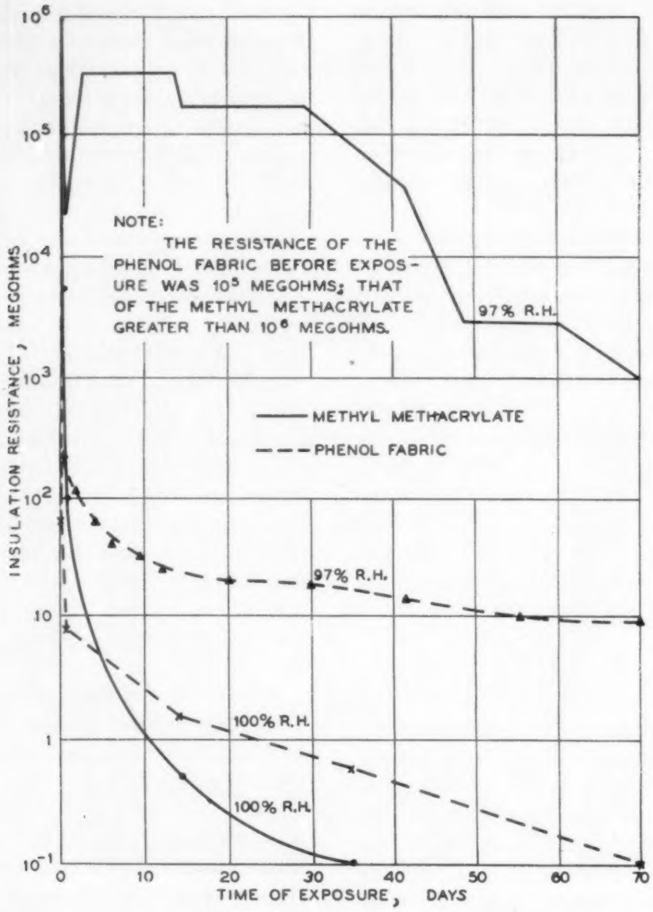



**Fig. 8.—Comparison of the Insulation Resistance of Phenol Fabric and Methyl Methacrylate at 100 Per Cent and 97 Per Cent Relative Humidity with Fungi Present.**

this additional cleaning of the surface, augmented by further drying, would result in an increase in insulation resistance. This terminal strip and the wood flour filled phenol plastic sample were dried in an oven at 110 C. for 2 hr. The resistance of the wood flour filled phenol plastic rose to 300,000 megohms and that of the glass mat laminate phenolic to 600. The glass mat laminate phenolic was dried for two additional hours at 110 C. Its resistance increased to 7300 megohms. After a total of 48 hr. at 110 C. it exhibited a resistance greater than 5,000,000 megohms.

The insulation resistance of the samples was redetermined after five more days over phosphoric anhydride. The wood flour filled phenol plastic showed a further increase to 450,000 megohms. The phenol fiber and phenol fabric both had a resistance over 5,000,000 megohms, as before, and the resistance of the glass mat laminate phenolic also now was as high as this. The glass-bonded mica had the same resistance as previously.

It is evident that none of the materials had been permanently affected by the prolonged exposure to fungi and high humidity and that cleaning of the surface coupled with the removal of the adsorbed and absorbed water restored the insulation resistance to its original high value.

To see how quickly these now high-resistance materials could be reduced again to a low-resistance level the samples were returned to the humidifier at 97 per cent relative humidity and 25 C. and their insulation resistance in megohms determined periodically at short intervals (Fig. 9). They showed a lesser change in insulation resistance early in the exposure period but soon reached the same levels of resistance they had with uncleaned surfaces (Fig. 3). The methyl methacrylate sample was not included because it had become badly cracked as a result of washing with ethyl alcohol. The alcohol apparently relieved stresses in the material caused by the insertion of the electrodes.

It is obvious that no fungus can grow rapidly enough to affect the insulation resistance in 1, or even in 6 hr., as much as shown in Fig. 9, nor can water absorption account for so great a change in so short a time. The effect probably is due entirely to the adsorption of water on the surface. In view of this there is not much point in protecting these insulating materials against fungi. To do so is equivalent to treating a symptom and ignoring the disease. In fact, moisture does its damage before fungi have time even to start growing.[4]

At the termination of this test the samples were examined under a microscope. The surfaces were clear. Only around the edges of the phenol fiber sample was there a very slight fringe of what might have been fungus growth.

It was decided to redry the test strips and coat the entire surface and terminals of each with a short oil varnish consisting of $12^1/_2$ gal. of tung oil to 100 lb. of paraphenylphenolformaldehyde resin. The varnished strips were to be exposed to 97 per cent relative humidity at 25 C. After $2^1/_2$ hr. at 110 C. and 4 days over phosphoric anhydride the resistance of the phenol fiber, glass-bonded mica, and glass mat laminate phenolic was brought back to more than 5,000,000 megohms, the resistance of the phenol fabric to 1,700,000 and of the wood flour filled phenol plastic to 130,000. The varnish then was applied with a brush and allowed to dry in the laboratory for 3 days before the resistance was remeasured. The insulation resistance in megohms of the varnished strips was as follows: phenol fiber, 110,000; phenol fabric, 730,000; wood flour filled phenol plastic, 42,000; glass-bonded mica greater

[4] Studies conducted by W. McMahon of these laboratories on the same materials at 100 per cent relative humidity show that the lowering of insulation resistance by condensed moisture overshadows that caused by fungus. However, in earlier studies with a different grade of wood flour filled phenolic, he observed a decrease from 100,000–200,000 to 0.05–0.2 megohm after 31 days' exposure to fungi at 100 per cent relative humidity; and, under the same conditions but using diphenylamine as a fungus inhibitor, a decrease to 7–9 megohms. While this again indicates that moisture is the major cause of the drop in resistance, a further lowering due to fungus on some insulating materials is a possibility.

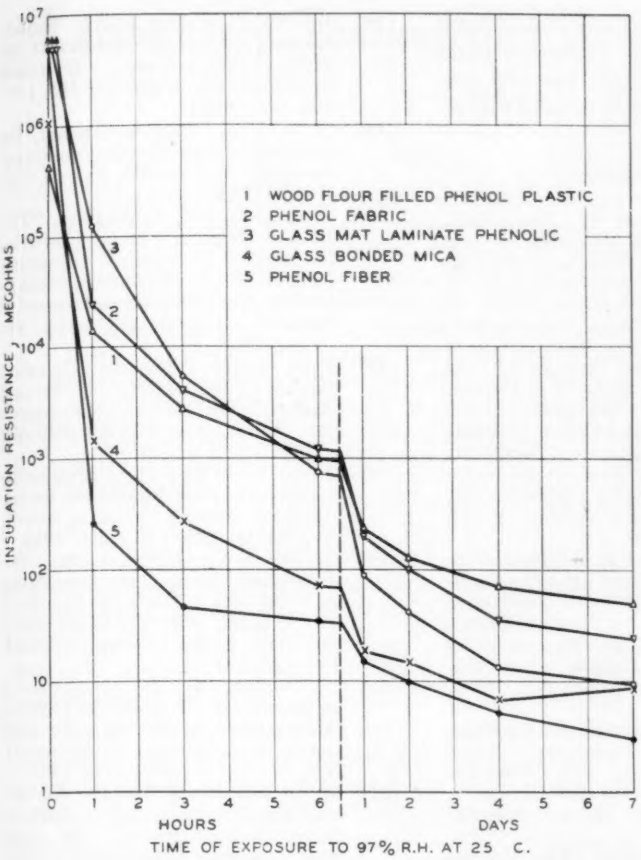



**Fig. 9.—Effect of High Humidity on the Insulation Resistance of Various Plastics with Clean Surfaces.**

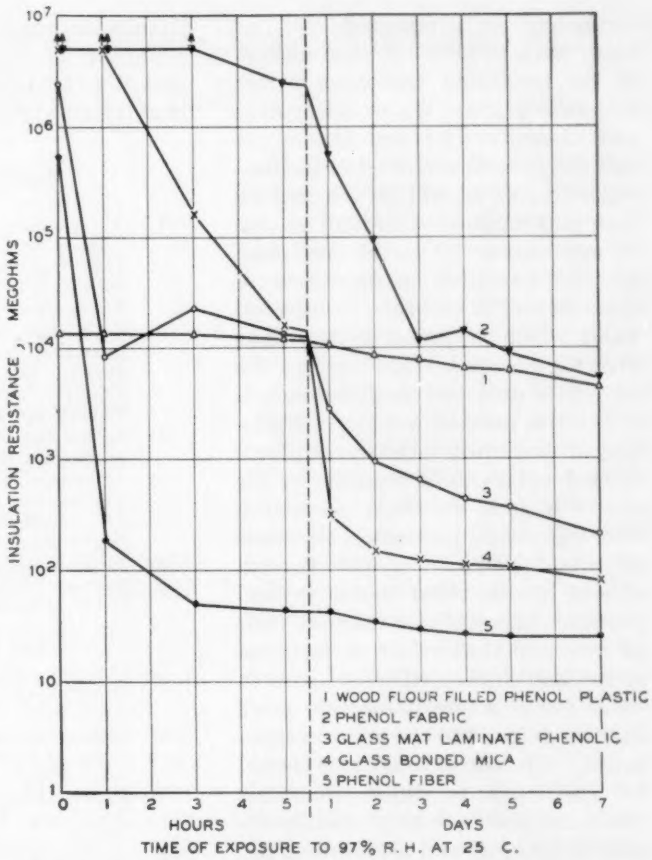



**Fig. 10.—Effect of High Humidity on the Insulation Resistance of Various Plastics with Varnished Surfaces.**

than 5,000,000; glass mat laminate phenolic, 1,700,000. It was necessary to dry these samples at 110 C. for 3 hr. and over phosphoric anhydride at 25 C. for 4 days to bring the resistance up to 560,000 megohms for the phenol fiber, greater than 5,000,000 for the phenol fabric and glass-bonded mica, and 2,500,000 for the glass mat laminate phenolic. The wood flour filled phenol plastic showed a drop in resistance to 14,000 megohms, probably caused by an accumulation of water at the plastic-varnish interface due to a difference in the rate of moisture diffusion. This phenomenon has been noted on other occasions.

The 97 per cent relative humidity test was started with the varnished strips at these resistance levels. The resistance in megohms, measured periodically at short intervals, decreased as shown in Fig. 10. No fungus growth was evident on any of the varnished surfaces.

It can be seen from the data in Figs. 9 and 10 that the application of a varnish brings about improvement by retarding, although not eliminating, the decrease in insulation resistance caused by moisture. These data, of course, concern only one varnish. The type used is extremely important. Another varnish might do better or actually bring about a worsening of the effect of water. In this connection it should be remembered that there are organic materials which absorb practically no water and yet allow a considerable amount to diffuse through (**13**, **26**).

### Discussion and Conclusion

The insulation resistance of the common commercial types of insulating materials made from organic and inorganic filled plastics may be so rapidly affected by water adsorption or condensation that equipment in which good insulation is required would be inoperative. Any further adverse effect on the insulation resistance by fungus growth on such materials is negligible. Dust, debris, or other contaminants which add to the wettability of the surface cause a more rapid lowering of the insulation resistance of some materials and comprise the chief food supply for subsequent fungus growth.

Measurements of the insulation resistance of a piece of stock methyl methacrylate show that condensed water will cause an immediate lowering. If condensation occurs on a plastic which neither absorbs nor is wetted by water it is found that when the surface is contaminated by water absorbing alien material there is a greater ultimate effect on insulation resistance. This same debris and not the plastic will again furnish food from which the water-absorbing fungus filaments can grow.

The chief source of confusion is the importance attributed to the end product in a degradation cycle, the fungus, and not to the more important intermediate and principal causes of electrical degradation. The presence of a lush growth of fungus in a piece of equipment is merely a warning signal that electrical dysfunction and trouble may be anticipated when operation of the

equipment is attempted. If no fungi were present the degradation of the insulation resistance would still take place. Water adsorption and absorption by the plastic are still the critical factors and insulating materials should be selected on their performance under high humidity conditions. This is confirmed by the practical observations of Gardner and Watt (10). Condensed water which is spread in thin films over the plastic surface through the agency of dust and similar debris is difficult to prevent but the degradation of insulation resistance by condensed water can be retarded by the use of a good envelope of varnish over the critical portions of electrical circuits. The use of the varnish should be restricted to the critical portions, especially at contact ends of wire and the surface of terminal strips, and eliminated from wiring in cable forms where it may do more harm than good to the primary insulation. The use of fungicides should be restricted to those materials which are known to be physically degraded by fungi and attempts to use them in inherently inert plastic materials should be discouraged.

To insure maximum operating life of equipment under adverse climatic conditions, moisture effects must be minimized. This can be accomplished by selecting insulating materials which adsorb and absorb the least water, by using thoroughly dried hermetically sealed apparatus or components, and designing equipment with heaters. Further important corrective measures are proper design, packaging, storage, and maintenance. Under actual service conditions moisture alone may be responsible for electrical failure. Surface debris on insulating materials may accelerate the rate of failure, but without these two factors fungi will not grow. If there is fungus growth a warning is present which indicates remedial measures should be taken before the equipment is used.

*Acknowledgment:*

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## References

(1) T. Akahira and M. Kamazawa, "The Effect of Humidity on the Loss Angle of Insulators," (In English) *Electrotechnical Journal*, Vol. 2, No. 6, June, 1938, p. 148.

(2) G. N. Bhattacharya, "On the Volume and Surface Resistivities of Shellac Moulded Materials," (In English) *Indian Journal of Physics*, Vol. 16, pp. 147–154 (1942).

(3) G. Bublitz, "The Effect of Moisture on Surface Resistance of Insulating Materials," (In German) *Archiv für Technisches Messen*, München 30, IX, T124–T126a, Lieferung 87, September, 1938.

(4) E. M. Cohn and P. G. Guest, "Influence of Humidity upon the Resistivity of Solid Dielectrics and upon the Dissipation of Static Electricity," United States Department of the Interior, Bureau of Mines, Information Circular No. 7286, June, 1944.

(5) Harvey L. Curtis, "Insulating Properties of Solid Dielectrics," Scientific Paper No. 234, Scientific Papers, Bulletin of the Bureau of Standards, Vol. 11, pp. 359–420 (1915).

(6) Harvey L. Curtis, "The Volume Resistivity and Surface Resistivity of Insulating Materials," *General Electric Review*, Vol. 18, pp. 996–1001 (1915).

(7) J. H. Dellinger and J. L. Preston, "Properties of Electrical Insulating Materials of the Laminated Phenol-Methylene Type," *Technologic Paper No. 216*, Nat. Bureau Standards, Vol. 16, pp. 501–627 (1922).

(8) "Tropical Moisture and Fungi May Sabotage Electrical Circuits," *Electrical Manufacturing*, Vol. 35, pp. 104–107, 184–192, June, 1945.

(9) S. Evershed, "The Characteristics of Insulation Resistance," *Journal*, Inst. Electrical Engineers., Vol. 52, pp. 51–73 (1914).

(10) D. H. Gardner and J. S. Watt, "Difficulties Encountered with Electronic Equipment in Humid Climates," Second Edition, October, 1944, Humble Oil and Refining Co., Houston, Tex.

(11) W. Gnann, "The Insulation Properties of Amber, Quartz, and Sulfur in Dry and Moist Air," (In German) *Physikalische Zeitschrift vereinigt mit dem Jahrbuch der Radioaktivität und Elektronik*, Vol. 36, pp. 222–230 (1935).

(12) C. P. Healy and J. C. Niven, "Mould and Humidity in Radio and Signals Equipment," *Proceedings*, Inst. Radio Engrs., Vol. 33, pp. 300–306, May, 1945.

(13) D. B. Herrmann, "Diffusion of Water through Organic Insulating Materials," *Bell Laboratories Record*, Vol. 13, pp. 45–48, (1934); *Rubber Age* (New York), Vol. 36, pp. 73–74, 78 (1934); *Rubber Chemistry and Technology*, Vol. 8, pp. 297–301 (1935).

(14) Wilfred F. Horner and F. Russell Koppa, "Tropical Treatment of Military Equipment," *Electronic Industries*, Vol. 4, pp. 106–108, 150–162, July, 1945.

(15) C. H. Hou, "Surface Conductivity of Cerein-Coated Quartz," *Review of Scientific Instruments*, Vol. 9, pp. 90–91 (1938).

(16) T. Kujirai and T. Akahira, "The Effect of Humidity on the Electrical Resistance of Fibrous Insulating Materials," (In Japanese) *Scientific Papers*, Inst. Physical and Chemical Research (Tokyo), Vol. 1, pp. 96–124 (1923).

(17) Ernst Leiste, "On the Electrical Surface Conductivity of Pressed Amber," (In German), *Zeitschrift für Physik*, Vol. 62, pp. 646–672 (1930).

(18) John Leutritz, Jr., "Protecting Communications Equipment for the Tropics," *Bell Laboratories Record*, Vol. 23, pp. 105–107, April, 1945.

(19) T. Miura and T. Kambara, "The Humidity Effect on the Loss Angle of Insulators at High Frequencies," (In English) *Electrotechnical Journal*, Vol. 3, No. 10, pp. 238–239, October, 1939.

(20) F. Moench, "On the Measurement of Insulating Materials at Definite Atmospheric Moistures," (In German), *Elektrotechnische Zeitschrift*, Vol. 50, pp. 929–930, June, 1929.

(21) Ryoji Nakazawa, Yoshito Takeda, and Shori Suematsu, "The Molds on Military Instruments," (In Japanese) *Journal*, Agricultural Chemical Soc. of Japan, Vol. 10, pp. 95–121 (1934).

(22) S. Okazaki and B. Itijo, "Humidity Effect on Dielectric Loss Angles at High Frequencies," (In English) *Electrotechnical Journal*, Vol. 3, No. 9, p. 210, September, 1939.

(23) R. Proskauer, "Fungus-Proofing Procedure," *Electronics*, Vol. 17, pp. 92–93, 224, 229, 232, June, 1944.

(24) R. Proskauer and H. E. Smith, "Fungus and Moisture Protection," *Electronics*, Vol. 18, pp. 119–123, May, 1945.

(25) Welby E. Stewart, "Receivers for the Tropics," *Electronics*, Vol. 14, pp. 28, 66, March, 1941.

(26) R. L. Taylor, D. B. Herrmann, and A. R. Kemp, "Diffusion of Water through Insulating Materials. Rubber, Synthetic Resins, and Other Organics," *Industrial and Engineering Chemistry*, Industrial Ed., Vol. 28, pp. 1255–1263 (1936).

(27) W. J. Tucker, "Tropic-proof Radio Apparatus," *Electronic Engineering*, Vol. 17, pp. 598–600, July, 1945.

(28) W. A. Yager, "Electrical Leakage Over Glass Surfaces," *Bell Laboratories Record*, Vol. 12, pp. 40–44 (1933).

(29) W. A. Yager, "Dielectric Constant and Dielectric Loss of Plastics as Related to Their Composition," *Transactions*, Electrochemical Soc., Vol. 74, pp. 113–134 (1938).

(30) W. A. Yager and S. O. Morgan, "Surface Leakage of Pyrex Glass," *Journal of Physical Chemistry*, Vol. 35, 2026–2042 (1931).

(31) The literature was searched from 1945 back to 1820, the year the galvanometer was invented, and no article on this subject was found.

# Laboratory Testing of Plastics—Small-Scale Flexure Test

By Owen W. Ward[1] and A. Bailey[1]


Synopsis

A method and apparatus for testing the flexural strength of plastics quantitatively was developed which yielded reproducible and accurate results on specimens of about 1 g. The apparatus and method of molding the required small beams of rectangular cross-section, and the apparatus and method of testing these beams are described and illustrated. Strength values for various plastics were determined by the reduced-scale test and the results tabulated. The precision of the method was of the order of one per cent and the accuracy was similar. The method permitted more rapid and economical experimental research on plastics by eliminating the preparation of large quantities of material in small-scale apparatus and by yielding test results on the change of one variable through a complete time-range from a single experiment.


Standard tests of the flexural strength of plastics require a specimen $\frac{1}{2}$ in. square and 5 in. long. Experimental work on plastics with chemical laboratory apparatus of common size may sometimes be accelerated if smaller samples, which will still provide reliable test data, can be substituted. Generally, similar advantages and disadvantages inhere in small-scale testing as in micro methods of analytical chemistry as compared to macro methods. Small-scale testing is not considered as a panacea or universal method, but it may have advantages in certain circumstances. Reduced-scale testing was employed by Jahn (**4**)[2] in the testing of plastics. A similar adaptation of the flexure testing of wood was made by Forsaith (**3**) and Schrader (**5**). Schrader's method required a specimen 12 in. long and 0.3 in. square; Jahn's 2.25 in. long, 0.47 in. wide, and 0.14 in. thick; and Forsaith's 2 in. long and 0.09 in. square. Only the specimen dimensions of Forsaith met our requirements, but his machine was expensive, slow and difficult to build, and impossible of attainment under war conditions. A new method was therefore developed of molding small beams 2 in. long and approximately 0.1 by 0.2 in. in cross-section and of testing these beams for flexural strength and modulus of elasticity. The apparatus employed was made in the laboratory from easily available materials.

## Molding of Specimens

Initial attempts to mold a small beam included the construction of a mold which produced a cylindrical beam about 2 in. long and 0.1 in. in diameter. The chase was bolted together and thus was separable. The upper and lower force plates were cylindrical and acted as pistons to compress the molding powder. Satisfactory beams were molded with materials of good flow properties, such as phenolics, but materials of less satisfactory flow produced inferior beams; hence the attempt to use cylindrical beams was discarded.

A mold for the production of rectangular beams was designed, constructed, and found to meet all requirements in tests. The mold was milled from square, cold-rolled iron rod and electroplated to withstand corrosion and prevent sticking. The general design of the mold is shown in Fig. 1.

The mold was prepared for loading by placing the assembled chase on the lower force plate and floating the chase $\frac{1}{4}$ in. above the force plate by inserting a U-shaped, removable shim between force plate and chase. The molding powder was weighed (usually about 1.1 g. was required for a beam 0.100 in. thick) and placed in the mold cavity. It was carefully distributed and tamped to a uniform density with a small spatula. If insufficient space existed to accommodate all the molding powder, the filled mold was squeezed in the press with the upper force plate in place, then removed and the remaining powder added. With the upper force plate in position, the mold was placed in the press, light pressure was applied, and the U-shaped shim removed to float the chase. The mold was heated by contact, above and below, by electrical heaters containing chambers into which water was forced for cooling at the end of each cycle. The time required to reach 250 C.—when this temperature was used on an experimental plastic (**1**)—from room temperature was about 20 min., and the cooling period from 250 to 75 C. was about 20 min., after which the pressure was released and the molded beam removed from the mold. For a commercial phenolic molding powder, satisfactory beams were produced by applying a pressure of 4000 psi., heating to 160 C. (requiring about 10 min.), holding at 160 C. for 5 min., and cooling to 75 C. (requiring about 10 min.) before taking out of

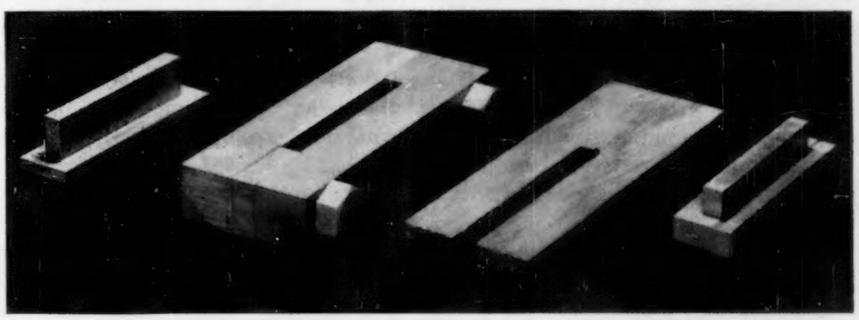

**Fig. 1.—Mold Used for Preparation of Rectangular Beams.**

From left to right: upper force plate, chase, shim used to float chase, lower force plate.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa.

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[2] Boldface numbers in parentheses refer to the list of references appended to this paper.

the press. The manufacturer's recommendation for this material was a molding pressure of 2250 to 4000 psi., and a temperature of 149 to 163 C. Manufacturers' specifications, similarly applied, yielded successful results on a number of com-

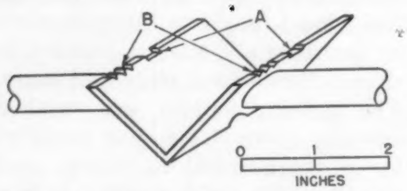


**Fig. 2.—Support for Holding Beams During Flexure Test.**

The beam was supported in notches *AA* while notches *BB* served as rests for the mirror mounting of the optical lever. Drawn to scale.

mercial plastics (1). Experimental molding powders often required special molding conditions dictated by the material itself. Temperatures were measured in thermometer wells in both of the electrical heaters with the mercury bulbs $\frac{1}{8}$ in. from the heater-mold contacts. Temperatures in the paired heaters were maintained at identical levels by means of suitable switches. After molding, the mold was disassembled, the specimen taken out, and the flash carefully removed. Freshly molded beams usually contained some moisture and other volatile material and required careful conditioning according to the specifications desired before testing for strength.

## Flexure Test Machine

The testing machine was designed with purposive disregard of earlier designs but with emphasis on fundamental correctness, accuracy of result, and ease of construction. The essential features of the machine included: (*a*) the beam support, (*b*) the device for loading the beam, and (*c*) the optical lever for measuring deflection of the beam (shown in Figs. 2, 3, and 4, respectively).

The beam support (Fig. 2) was constructed from $1\frac{1}{2}$-in. (equal) angle iron, $1\frac{3}{4}$ in. long, to which were brazed $\frac{1}{2}$-in. iron rods for clamping in the usual right-angle laboratory clamps.

An end view of the testing machine assembly, including the loading device and mechanical parts of the optical lever system, is shown in Fig. 3.

The load was suspended from the stirrup by a swivel and hook which supported a 2-gal. can. The stirrup rested on the beam in a flat, milled contact, $\frac{1}{16}$ in. wide. Load was applied to the beam by adding water to the can at a constant, calibrated rate from a constant level device.

The rigidity of the mirror mounting and support was of the greatest importance. The distances between the rear edge of the beam notch and the three mirror notches was $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ in., respectively. The outer, or $\frac{1}{2}$-in., notch was used principally and with a reflected beam 20 ft. long gave a magnification of 665–680

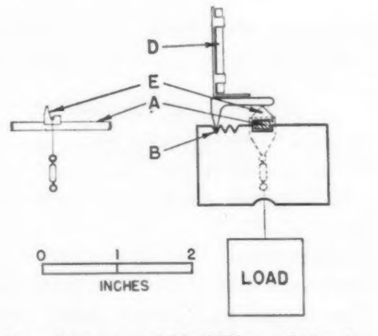


**Fig. 3.—Diagram of End View of Testing Assembly.**

Small diagram at left is front elevation of beam and stirrup from which load was suspended. The beam *A* was mounted in the beam notches and supported the stirrup *E* in the center of the beam. The mechanical part of the optical system consisted of mirror *D* fixed in a three-point mounting. Two of these points were supported in notch *B* and the third point rested on the tip of the stirrup. When the beam and stirrup deflected, the mirror rotated about *B* as a center. Drawn to scale.

to 1, depending on the thickness of the beam. Optical definition permitted reading of the scale to $\frac{1}{32}$ in.; thus deflections of the beam of 0.00005 in. could be measured. The use of the $\frac{1}{4}$-in. notch and an unsymmetrical stirrup gave a magnification of 2813 to 1 and permitted measurement of 0.00001 in. The optical lever was calibrated by loading a beam and taking simultaneous readings with the optical lever and with a dial indicator reading to 0.0001 in. The average value of the beam deflection over 0.1 in. was used to calibrate the optical lever.

The optical system is illustrated in Fig. 4. The light source was a 32-candle power, 6-v. lamp, operated at 8 to 10 v. The lamp housing permitted rotation and three-dimensional alignment of the filament with the doublet condensing lens.

The entire testing assembly was adjusted and then left in the same fixed position; only the beam, stirrup, load, and mirror needed resetting for a new test. A photograph of the assembly set up for testing is shown in Fig. 5.

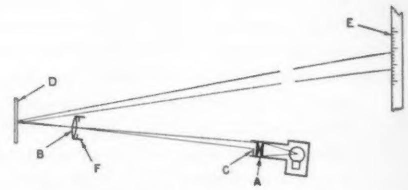


**Fig. 4.—Optical System for Measuring Deflection in Flexure Test.**

The doublet condensing lens *A* (focal length, 4.5 cm.) focused an image of the filament on the back of the projection lens *B* (focal length, 50 cm.), which was focused to form a sharp image of the knife-edge *C* on the scale *E* after reflection by mirror *D*. The field diaphragm *F* restricted chromatic and spherical aberration from the outer margin of the projection lens.

## Testing Procedure

Molded beams were conditioned according to the specifications required: freshly molded beams were tested immediately after molding with no conditioning. Others were carefully conditioned at 50 C. for 48 hr. in accordance with A.S.T.M. Method D 618 – 45 T,[3] immersed in water at room temperature for 48 hr. (A.S.T.M. Method D 570 – 42[4] but longer time), or oven dried.

[3] Tentative Methods of Preconditioning of Plastics and Electrical Insulating Materials for Testing, 1945 Supplement to A.S.T.M. Book of Standards, Part III, p. 257.

[4] Standard Method of Test for Water Absorption of Plastics, 1944 Book of A.S.T.M. Standards, Part III, p. 543.

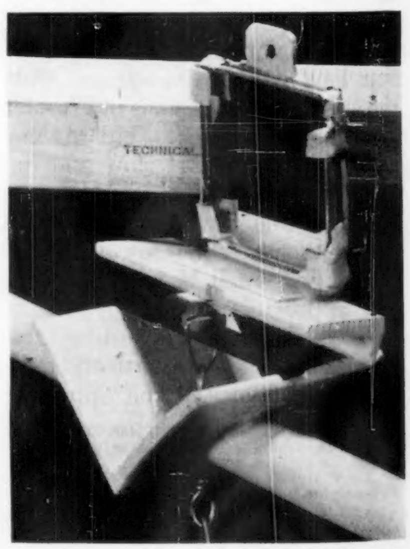

**Fig. 5.—Flexure Test Machine Assembled.**

After the appropriate conditioning, the beam was set in the beam notches, the stirrup centered on the beam, and the mirror and support set in place. Water was added to the container at a constant rate of approximately 1.9 lb. per min. The beam was loaded until failure occurred, noting deflection at no load, load with container only (625 g. (1.379 lb.)) and at 30-sec. intervals thereafter, until the final time interval when failure occurred. In computing the mechanical properties, the time intervals were converted to loads from the calibration of the rate of loading the water contained. It was imperative that the temperature of the water be constant during calibration and identical in loading the beam, since the rate of flow varied considerably with temperature.

It proved of considerable value to attach alligator clips secured by a cord to the halves of the beam which later broke into two pieces, thus eliminating hunting for the pieces to be used for further tests and for the determination of exact dimensions. The water container hung freely without any part of the loading system touching any of the fixed parts of the supporting system, and at failure dropped approximately $\frac{1}{2}$ in. to a mat of sponge rubber $\frac{1}{2}$ in. thick. The breadth and height of the broken beam were measured at the break with a micrometer to the nearest micron.

Stress-strain curves were plotted with load over deflection. The modulus of rupture was calculated from the load at rupture and the modulus of elasticity from the proportionality of the straight portion of the stress-strain curve. The following equations were used:

$$\text{Modulus of rupture } (R) = \frac{1.5PL}{bh^2}$$

$$\text{Modulus of elasticity } (E) = \frac{P_eL^3}{4bh^3Y_e}$$

where:

$P$ = load at rupture,
$L$ = length of beam,
$b$ = breadth of beam,
$h$ = height of beam,
$P_e$ = load at proportional point, and
$Y_e$ = deflection at proportional point.

## Results of Tests on Plastics

Molding powders of commercial plastics as well as molding powders of experimental plastics were molded into test beams and tested by the reduced scale test. The results of some of these tests, together with the values—when known—as determined by the A.S.T.M. Tentative Method D 48 - 33 T[5], are shown in Table I.

In addition to the above data on the reproducibility of the reduced flexural test on plastics, experiments were carried out to determine the reproducibility on a more homogeneous test material. Three different 2-in. sections were milled from the same hot-rolled iron strap. Each section was milled accurately on all sides to the average dimensions of the plastic beams and each section was tested separately. Due to the relatively high modulus of elasticity of the material, the deflection at full load was only a portion of that which could have been supported

[5] Tentative Methods of Testing Molded Materials Used for Electrical Insulation, 1945 Supplement to 1944 Book of A.S.T.M. Standards, Part III, p. 260.

TABLE I.—MODULUS OF RUPTURE AND ELASTICITY OF PLASTICS BY REDUCED SCALE TEST.

| Designation of Plastic | Composition of Plastic | Modulus of Rupture, psi. | Modulus of Elasticity, psi. × $10^5$ | Conditioning of Beam for Test |
|---|---|---|---|---|
| Commercial plastic A | High-impact phenolic | 12 100 | 9.21 | 24 hr. at 105 C. |
| | | 8 400 | 9.00 | 48 hr. at 50 C. |
| | | 11 900 | 8.55 | 24 hr. at 105 C. |
| | | 12 200 | 8.20 | 48 hr. in $H_2O$[a] |
| | | 11 300 | 7.72 | 48 hr. in $H_2O$[a] |
| | | 10 000[d] | 10.0 [d] | 48 hr. at 50 C.[d] |
| Piece cut from a stock sheet of phenolic | Phenolic | 13 900 | Not measured | Room environment of stock sheet |
| Commercial plastic B | Acrylic | 9 600 | 3.57 | 24 hr. at 105 C. |
| | | 10 500 | 3.44 | 48 hr. in $H_2O$[a] |
| | | 9 500 | 3.59 | 48 hr. in $H_2O$[a] |
| Commercial plastic C | Maple "lignocellulose" (hydrolyzed wood) | 8 100 | 9.60 | 24 hr. at 105 C. |
| Commercial plastic D | Same as A with phenolic resin added | 9 200 | 11.18 | 24 hr. at 105 C. |
| | | 8 100 | 14.00 | 48 hr. at 50 C. |
| | | 9 500 | 11.16 | 24 hr. at 105 C. |
| | | 9 200 | 10.50 | 48 hr. in $H_2O$[a] |
| Commercial plastic E | Redwood "lignocellulose" and furfuryl alcohol resin | 6 100 | 11.00 | 24 hr. at 105 C. |
| Western White Pine (*Pinus monticola*) | One annual ring in width | 11 600 | 7.50 | Air dried, room temperature |
| Butasin[e] | Lignin resin alone | 8 200 | 3.77 | Green[b] |
| | | 10 600 | 3.95 | Green[b] |
| | | 7 900 | 3.83 | Green[b] |
| | | 12 800 | Not tested | 24 hr. at 105 C. |
| | | 6 700 | Not tested | 48 hr. in $H_2O$[a] |
| | Contained 10% of tricresyl phosphate | 9 000 | 3.30 | 48 hr. at 50 C. |
| | Contained 10% of *o*, *p*, toluene sulfonamide | 8 500 | 3.90 | 48 hr. at 50 C. |
| | Contained 10% of triethyl citrate | 11 500 | 4.15 | 48 hr. at 50 C. |
| | Contained 10% of butyl phthalyl butyl glycollate | 10 600 | 3.60 | Green |
| | 50% wood flour | 3 700 | 3.21 | Green |
| | 50% cotton fibers | 4 100 | 3.30 | Green |
| | 25% cotton fibers | 7 200 | 4.50 | Green |
| | About 15% glass fibers | 3 000 | 6.10 | Green |
| | With 10% tricresylphosphate and 5% cotton filler[c] | 11 400 | 5.76 | 24 hr. at 105 C. |
| | | 9 200 | 5.36 | 48 hr. in $H_2O$[a] |

[a] At room temperature.
[b] Tested immediately after molding, no pre-treatment.
[c] Actual ratio was butasin:tricresyl phosphate:cotton staple = 100:10:5.5.
[d] A.S.T.M. values from reference 2.
[e] Reference 1.

but was on the straight portion of the stress-strain curve. The modulus of elasticity was calculated from this proportionality. The results of these tests are shown in Table II.

TABLE II.—REPRODUCIBILITY AND ACCURACY OF MEASUREMENT OF MODULUS OF ELASTICITY OF HOT-ROLLED IRON BARS.

| | Bar Tested | Modulus of Elasticity Found, psi. $\times 10^6$ | Deviation from Average $E$, per cent | Deviation from $29 \times 10^6$ psi., per cent[a] |
|---|---|---|---|---|
| Dial gage to determine deflection at known load | No. 1 | 29.20 | +0.03 | +0.69 |
| | No. 2 | 28.90 | −0.99 | −0.34 |
| | No. 3 | 28.75 | −1.51 | −0.86 |
| Mirror to determine deflection at known load | No. 1 | 29.62 | +1.47 | +2.14 |
| | No. 2 | 28.95 | −0.82 | −0.17 |
| | No. 3 | 29.77 | +1.82 | +2.67 |
| Average of tests | Nos. 1, 2, 3 | 29.19 | 1.10 | 1.14 |

[a] Accepted modulus of elasticity for iron.

From the data in Table II the reproducibility of the test would appear to be of a satisfactory order.

The accuracy of the test on metals may be inferred from the modulus of elasticity found for the iron beams. The usual engineering value accepted for this material is 29,000,000 psi. It probably is correct to assume a similar accuracy on plastics. One distinction must be considered, however. Metals are relatively homogeneous, aeolotropic, and lack skin effect. In plastics, skin effect and laminar flow give rise to different strength values for different thicknesses of material. Although this might lead to the conclusion that the reduced-scale test was inaccurate in correlating it with the A.S.T.M. test, it is probable that the small test measured strengths accurately but that the values were actually different from that found in larger specimens, due to such phenomena as more uniform curing in thin sections, different pressure distribution, greater skin effect in relation to thickness, laminar flow, etc. Accordingly, it would appear that the reduced test might be used to obtain quantitative data on the strength of the skin contrasted with interior of plastics to determine whether the skin is stronger and to what degree. The actual heterogeneities of plastics from specimen to specimen are not inconsiderable, leading to a wider range of strength values than in the case of metals. Some of the phenomena noted above were actually observed, especially the heterogeneity of molding powders filled with staple fiber.

It seems probable that the reduced method could be applied to the testing of any plastic, ceramic, wood, or other materials of construction.

## Discussion

The quantitative results obtained with the reduced-scale test would appear to support the point of view that the rectangular beams were uniform, that the mold design was valid, and that bridging of molding powder, laminar flow, etc., were eliminated or minimized.

The reduced-scale testing method proved to be of great value in the experimental development of plastics (**1**). It was used primarily as a research control method permitting rapid testing of the effect of changing a given variable in the preparation or formulation of plastics. The reproducibility of the test was greater than the uniformity of the materials tested. The accuracy of the method appeared to be satisfactory, while the correlation of the reduced-scale with the standard A.S.T.M. test remains to be established. The small-scale test offered important economies to us in the time and materials required for experimental research in plastics. Flexural and impact strengths, modulus of elasticity, specific gravity, and water absorption were all determined on a sample of about 1 g. of material or less. This permitted not only the use of apparatus of standard chemical laboratory size, but also made possible, in a single experiment, following the effects of changing a given variable through a complete time range, by withdrawing 1-g. samples at intervals, and finally molding and testing each of these samples. The molding and testing procedure required about the same time, skill, and care as the large-scale test.

## References


(**1**) A. Bailey and O. W. Ward, "Synthetic Lignin Resin and Plastic," *Industrial and Engineering Chem.*, Vol. 37, pp. 1199–1202 (1945).

(**2**) Bakelite Molding Material, *Technical Data*, Sheet BM 6260 Black, Series I, New York, Bakelite Corp. (1936).

(**3**) C. C. Forsaith, "Strength Properties of Small Beams of Southern Yellow Pine," N. Y. State College of Forestry *Tech. Pub. No.* 42, pp. 1–37 (1933).

(**4**) E. C. Jahn, *et al.*, "Testing Samples of Molded Wood or Fiber Products," *Paper Ind. and Paper World*, Vol. 20, pp. 761–764 (1938).

(**5**) O. H. Schrader, Jr., "Influence of Specific Gravity and Certain Anatomical Features on the Strength Properties of Small Douglas Fir Beams," New Haven, Yale School of Forestry, Ph.D. Thesis, 1942.

# Corrosion Criteria—Their Visual Evaluation


## By Marc Darrin[1]



SYNOPSIS

A.S.T.M. has been instrumental in the standardization of procedures for conducting corrosion tests.[2] The chief criterion of severity of attack is weight loss of metal, provided there is no local corrosion; but specifications are inadequate as to what constitutes local attack and how it should be reported or evaluated. In this report are suggested standardized terms and procedures for describing and reporting various types of aqueous corrosion, particularly when of a localized nature. It includes a description of laboratory report forms and how they are used to obtain and interpret corrosion scores, chiefly by visual inspection. The method is simple and can be learned quickly. It has proved satisfactory over a period of six years (**4**).[3]


PANELS exposed in aqueous media frequently do not corrode uniformly. Many show signs of local attack, especially on edges or corners. For these panels weight-loss comparisons are meaningless (**2**) unless made between panels having essentially the same type of corrosion. An opinion as to the reliability of these comparisons may be based on the nature of the localized corrosion. Obviously if localized corrosion is limited to pits of about the same number and depth on two panels, their relative order of corrosion resistance may be based on weight loss—but the primary criterion which places these two panels in the same class is the nature of the corrosion.

## VISUAL SCORING

For these reasons our laboratory, for the past six years, has used a visual scoring method supplemented by the customary weight-loss data. Scores are obtained by marking various criteria of corrosion on a prepared form (Form 1) which is converted to a numerical basis by weighting the importance of each corrosion criterion for the particular application under consideration. A method of doing this has been described by the author (**2**). A somewhat similar but more complicated method of visual comparison has since been suggested by F. A. Champion (**1**). Although the latter method is very good from the theoretical viewpoint, there are several reasons which limit its practical application: first, its complication and use of special radiographic equipment; second, the use of seven terms to differentiate degrees of corrosion, namely, (1) minute, (2) very small, (3) small, (4) moderate, (5) considerable, (6) large, and (7) very large. These words represent too small differences to be duplicated by independent observers.

In the present procedure only four terms are used to describe the amount of local corrosion, namely, (1) none, (2) slight, (3) moderate, and (4) bad. It has been found that almost anyone with a little experience can check on a prepared form whether local corrosion is slight, moderate, or bad. Having done this the observer checks on the next line (Form 1, section *A*) whether the depth of the local corrosion is slight, moderate, deep, or very deep. Ordinarily this can be judged by the eye; however, if depth measurements are made, the relation shown in Table I may be employed (**3**).

TABLE I.—GENERAL MEANING OF PIT-DEPTH TERMS (**3**).

| Designation | Depth of corrosion, in. |
|---|---|
| None | <0.001 |
| Slight | 0.001 to 0.004 |
| Moderate | 0.005 to 0.014 |
| Deep | 0.015 to 0.030 |
| Very deep | >0.030 |

*Roughening:*

In a similar manner evidence of general corrosion is checked. Other corrosion criteria such as discoloration and roughening are checked also. The degree of roughening corresponds to Champion's (**1**) "even" and "uneven" types of corrosion, but the method described here is simpler. It amounts to deducting more for local corrosion than for general corrosion, deducting a little more if either are roughened, and still more if pitted, the precise amount of each deduction being based on three or four readily discernible degrees. The figures given in Form 1 automatically provide for these deductions.

*Corrosion Score of Panel:*

Having checked the degree of all corrosion criteria on the prepared form, the numerical values assigned to each are added. For example, if the specimen was badly attacked in respect to all corrosion criteria, values on the extreme right (Form 1, section *A*) would be checked and their sum would be zero. The sum of the values at the extreme left is 40, which represents a perfect specimen. The obtained sum may be converted to the basis of 100 equals a perfect panel by dividing by 0.4, but this is the corrosion score of the panel only, not of the system.

*Bimetallic Systems* (**2**):

If the system is bimetallic, section *B*, Form 1, should be checked for the contact metal; but, since this metal is usually cathodic and has almost a perfect score, namely, 40, its detailed inspection is not always essential. For instance, if copper is in contact with an iron panel, in an ordinary aqueous medium, it is permissible to assume that the corrosion score of the copper is 40, unless it happens that discoloration of the copper is of some importance in which case the score of the copper may be reduced from 1 to 3 points as provided in the form.

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[2] Standard Recommended Practice for Conducting Plant Corrosion Tests (A 224 – 41), 1944 Book of A.S.T.M. Standards, Part I, p. 522.
Tentative Method of Total Immersion Corrosion Tests of Non-Ferrous Metals (B 185 – 43 T), 1944 Book of A.S.T.M. Standards, Part I, p. 1850.
Tentative Method of Alternate Immersion Corrosion Test of Non-Ferrous Metals (B 192 – 44 T), 1944 Book of A.S.T.M. Standards, Part I, p. 1783.
Reports of Committee A-5 on Corrosion of Iron and Steel, *Proceedings*, Am. Soc. Testing Mats.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

*Liquid Media:*

If the condition of the liquid is important, as in a recirculating cooling water system (**6**) or refrigeration brine (**7**), section *C*, Form 1 should be checked. If the condition of the liquid is of no importance, its score may be considered as 20. Likewise any other corrosion criterion which is of no importance for a particular application may be scored as perfect when making comparisons for that particular application.

*Corrosion Score of System:*

The sum, $A + B + C$ (Form 1), is the corrosion score of the system on the basis of 100 equals a perfect system. If there is no contact metal, or if the contact metal is unattacked or its condition unimportant, *B* equals 40. If there is no contact metal in a series of tests which are being compared only between themselves, it is permissible to disregard factor *B* and compare on the basis of 60 equals perfect. As mentioned, if the condition of the liquid is of no importance, factor $C$ may be considered as 20.

Various modifications of the above procedure and weightings have been tried, and it has been found that the one described is most generally applicable. Irrespective of what weightings are used, the data may be recalculated at any time for special comparisons or for other weightings which may be decided upon later.

*Meaning of Corrosion Score* (**4**):

Sometimes it is more convenient to designate the general degree of corrosion resistance as "good," "bad," etc., rather than by a numerical corrosion score. A system for doing this is shown in Table II. This method of indicating corrosion resistance by a descriptive word rather than a score number is advantageous in comparing systems which are not closely related, or systems where there has been very severe corrosion. This is because a few points of difference may have no significance for such comparisons.

TABLE II.—GENERAL MEANING OF CORROSION SCORE (**4**).

| Designation | Score | Degree of Corrosion |
|---|---|---|
| Perfect...... | 100 | No indication |
| Excellent.... | Above 95 | Minor, but very satisfactory |
| Good........ | 85 to 95 | Definite, but probably satisfactory |
| Fair......... | 75 to 84 | Questionable |
| Poor........ | 65 to 74 | Probably unsatisfactory |
| Bad......... | Less than 65 | Severe corrosion |

## Personal Factor

All corrosion tests during the past six years were checked with close agreement by four men, one of whom was the author, and one of whom was usually a new man with little or no corrosion experience. After examination of a few panels there was almost no difference between the results reported by a new man and an experienced man. These tests included several thousand panels of ferrous and non-ferrous metals, and bimetallic combinations, in various media for long periods of time under a variety of conditions (**2–5**).

## Types of Corrosion

It has been found very helpful, in addition to the foregoing, to indicate in more detail the types of corrosion. In order to do this each type of corrosion, as it appears to the eye on the cleaned panel, may be assigned a number, which is recorded in the sequence of its predominance. The numbers which were assigned to the various types of corrosion about three years ago have been previously reported (**4**). These numbers provide information both as to the character and location of the corrosion. With this informa-

*FORM 1.—VISUAL INSPECTION BEFORE CLEANING* (**2, 3**).

Sample No.——————Ref. No.——————Time Exposed——————Temp.——————
Description ——————————————————————————

*A.* CONDITION OF SPECIMEN (40)

1. Discoloration (none 3, slight 2, moderate 1, bad 0)
2. Roughening (none 4, slight 3, moderate 2, bad 0)
3. Local corrosion (none 9, slight 6, moderate 3, bad 0)
4. Depth of pits (none 12, slight 9, moderate 6, deep 3, very deep 0)
5. General corrosion (none 12, slight 9, moderate 6, bad 3, very bad 0)

*B.* CONDITION OF CONTACT METAL IF PRESENT (40)

1. Discoloration (none 3, slight 2, moderate 1, bad 0)
2. Roughening (none 4, slight 3, moderate 2, bad 0)
3. Local corrosion (none 9, slight 6, moderate 3, bad 0)
4. Depth of pits (none 12, slight 9, moderate 6, deep 3, very deep 0)
5. General corrosion (none 12, slight 9, moderate 6, bad 3, very bad 0)

*C.* CONDITION OF LIQUID (20) ——————————

1. Cloudiness (none 4, slight 3, moderate 2, bad 0)
2. Precipitate (none 8, slight 5, moderate 2, bad 0)
3. General appearance (good 8, fair 6, poor 4, bad 2, very bad 0)

CORROSION SCORE ($A + B + C$) ——————————
REMARKS: ——————————————————————————

Date—————————— Observer——————————

*FORM 2.—EXAMINATION AFTER CLEANING* (**4**).

Sample No.——————Ref. No.——————Time——————Area——————Metal——————
Weight loss:——————g.——————mdd*——————ipy**
Appearance of cleaned panel (excellent, good, fair, poor, bad, very bad)

| Corrosion Types | Order | Number | Depth |
|---|---|---|---|
| 1. Discoloration.............................. | ——— | | |
| 2. General corrosion, even.................... | ——— | | |
| 3. General corrosion, uneven.................. | ——— | | |
| 4. Large local corrosion areas, even.......... | ——— | | |
| 5. Large local corrosion areas, uneven........ | ——— | | |
| 6. Wide pits.................................. | ——— | ——— | ——— |
| 7. Elongated pits............................. | ——— | ——— | ——— |
| 8. Medium or rounded pits..................... | ——— | ——— | ——— |
| 9. Narrow pits................................ | ——— | ——— | ——— |
| 10. Blister pits............................... | ——— | ——— | ——— |
| 11. Erupted pits............................... | ——— | ——— | ——— |
| 12. Perforation of coating..................... | ——— | ——— | ——— |
| 13. Perforation of panel....................... | ——— | ——— | ——— |
| 14. Cracks..................................... | ——— | ——— | ——— |
| 15. Edge or corner corrosion................... | ——— | ——— | |
| 16. Attack near bimetallic contact............. | ——— | ——— | |
| 17. Water line corrosion....................... | ——— | | |
| 18. Selective attack........................... | ——— | | |
| 19. Erosion.................................... | ——— | | |
| 20. Defects or injury.......................... | ——— | | |

*Media Analysis*, at start——————
at end——————
pH at start——————at end——————
Compare with——————————
Remarks: ——————————————————————————

*Directions:* In the column marked "number" record the number of pits on the panel (including edges) per 12 sq. in. of surface up to >5 pits. Under "depth" show the depth of the deepest pit to the closest thousandth-inch from <0.001 to >0.030 in. (exclusive of pits whose centers are less than 1/8 in. from edge). Under "order" check the predominating types of corrosion, and indicate their relative order of severity.

* Milligrams per square decimeter per day.

** Inches penetration per year.

tion accompanying customary corrosion data, reliable recommendations for specific applications may be made by an experienced engineer.

The arrangement of these corrosion type numbers was an arbitrary one which had grown and was changed from time to time as difficulties were encountered. This arrangement, though quite satisfactory for most practical applications, has limitations; and the selection of names and their sequence is not very logical from the theoretical viewpoint. For these reasons a revised arrangement with better nomenclature is suggested, as shown in Form 2. This has two classes of general corrosion, namely, even and uneven; two intermediate classes of local corrosion are provided between general corrosion and wide pits; and dezincification is included under the general classification of selective attack.

Undoubtedly other improvements can be suggested, and this is one of the purposes of this discussion. Equally important is bringing to the attention of various A.S.T.M. corrosion committees the desirability of uniform nomenclature for different types of corrosion, and eventually assigning a number or other symbol to each. Of course it would be desirable to do this before the present procedure becomes too firmly established.

### Summarized Procedure

1. *Before cleaning* the panel, its appearance is checked on section *A* of Form 1. If the system is bimetallic, the contact metal is checked on section *B*. If the condition of the liquid is of importance, this is checked on section *C*. Any criteria that are unimportant for a particular application may be checked as perfect when comparisons are required only for that particular application. The sum of the corrosion criteria weightings is the score. The general meaning of this score is shown in Table II; but, in order to reevaluate for specific applications, the following more detailed information may be required:

2. *After cleaning* the panel, the types of corrosion may be classified in greater detail on Form 2. Spaces are provided also on this form for analysis of liquid, pH changes, general appearance, weight loss and derived data.

3. *To compare panels* or systems, the principal data on Forms 1 and 2 are recapitulated. This may be done on a third form (not shown) having columns for tabulation of the following information, as may be pertinent for the application under consideration: panel number; conditions of test; analysis of liquid; inches penetration per year; types of corrosion, recorded in sequence of severity; depth of deepest pit, followed by its type symbol; corrosion score of system or panel; appearance of cleaned panel.

If there is no significant difference (other than weight loss) between the above data for panels that are being compared, their order of corrosion resistance may be based on weight loss figured as inches penetration per year. Otherwise, they should be divided into groups such as those shown in Table II. Those in the top groups which do not show signs of severe local attack may be arranged in order of inches penetration per year; while those in lower groups should be arranged according to depth of pitting or other criteria of local attack.

### References


(1) F. A. Champion, "New Methods for the Examination of Corroded Metal," *Journal*, Inst. Metals (London), Vol. 69, pp. 47–66 (1943).

(2) Marc Darrin, "Chromate Corrosion Inhibitors in Bimetallic Systems," *Industrial and Engineering Chemistry*, Anal. Ed., Vol. 13, pp. 755–759 (1941); *Proceedings*, Ann. Water Conference, Engineering Soc. Western Pennsylvania, Vol. 2, pp. 59–69 (1941).

(3) Marc Darrin, "Chromate Corrosion Inhibitors in Brine Systems," *ASRE Corrosion Report*, Am. Soc. Refrigerating Engineers, pp. 21–27 (1944).

(4) Marc Darrin, "Chromate Corrosion Inhibitors in Bimetallic Systems—Technology under Conditions Encountered in Practice," *Industrial and Engineering Chemistry*, Vol. 37, pp. 741–749 (1945).

(5) Marc Darrin, "Chromate Corrosion Inhibitors in Chloride Systems—Rate of Consumption of Chromate," *Industrial and Engineering Chemistry* (to be published).

(6) Mutual Chemical Company of America, "Chromate Corrosion Inhibitors for Internal Combustion Engines," Serial No. 33 (1945).

(7) Mutual Chemical Company of America, "Corrosion Control in the Refrigeration Industry—The Chromate Treatment of Brine," Serial No. 34 (1946).


# The Knoop Indenter as Applied to Testing Nonmetallic Materials Ranging from Plastics to Diamonds


## By Vincent E. Lysaght[1]


Indentation hardness tests have been used as a means of checking the uniformity of the mechanical properties of metals since about 1900 when J. A. Brinell published the results of his tests on pressing steel balls into materials, followed by the development of the scleroscope method and the introduction of the Rockwell hardness tester.

The invention by the late Frederick Knoop of the National Bureau of Standards (**1**)[2] of a new type of indenter and the development of the Tukon tester (Fig. 1) by the Wilson Mechanical Instrument Co., Inc., offer a new field for indentation hardness testing. The so-called Knoop indenter is made of diamond and ground to a pyramidal form that produces a diamond-shape (Rhomb) indentation having long and short diagonals of approximately 7 to 1 ratio. The included longitudinal angle is 172 deg. 30 min. and the included transverse angle is 130 deg. The depth of indentation is about one thirtieth of its length. The Tukon tester is an instrument capable of applying

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[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

light loads—even down to 25 g. In combination with the new, sensitive shaped indenter, hardness determination of extremely thin material and of hard and brittle materials is made possible. The indentation number is taken as the ratio of the applied load to the unrecovered projected area. The length of the long diagonal is the only measurement required and from this length the number is calculated, since this length is but little affected by elastic recovery when the load is removed.


**Fig. 1.—The Tukon Tester.**

A complete description of the Knoop indenter is found in the National Bureau of Standards Paper RP1220 (**1**).

The use of this indenter for testing metals has been described in detail elsewhere by the author (**2**) and the present paper will discuss the use of the Knoop indenter for testing nonmetallic materials. S. R. Williams (**3**) points out that if hardness is a physical property, it must be universal for all solids and not of metals alone, whether the solid materials be wax, wood, minerals, plastics, electrical insulating materials, or such protective coatings as paint, lacquers and shellacs. The Knoop indenter and Tukon tester offer a means to explore this conception.

The ordinary loads and indenters as used with the Rockwell and the Brinell testers cause brittle material, such as glass and ceramics, to shatter under the applied load. Furthermore, they produce far too deep a penetration to test thin coatings. The Knoop indenter, on the other hand, with loads as light as 25 g. can be used to obtain an impression which has good definition and this may be important in making certain types of tests for example, testing the protective coatings referred to above. At the same time, it has been found that the Knoop indenter can be used for testing brittle materials using loads up to a few thousand grams.

Minerals and hard abrasives have in general been rated for hardness chiefly by the Mohs scale (**4**). Some attempts have been made to correlate the Mohs scale with Brinell hardness for metallic materials (**5**), but, generally speaking, no quantitative values were associated with the scale. Table I published by Knoop and Peters (**6**), and later modified slightly, gives indentation hardness numbers for minerals and some hard abrasives ranging from soft gypsum to diamond. This table gives one an idea of the range of materials which may be tested with the Knoop indenter and some specific applications are described below.

TABLE I.—KNOOP HARDNESS OF MOHS MINERALS AND ABRASIVE MATERIALS.

| Samples | Knoop Numbers |
|---|---|
| Gypsum | 32 |
| Calcite | 135 |
| Fluorite | 163 |
| Apatite parallel to axis | 360 |
| Apatite perpendicular to axis | 430 |
| Albite | 490 |
| Orthoclase | 560 |
| Crystalline quartz parallel to axis | 710 |
| Crystalline quartz perpendicular to axis | 790 |
| Topaz | 1250 |
| Carboloy | 1050 to 1500 |
| Regular alundum No. 1 | 1635 |
| Regular alundum No. 2 | 1625 |
| Regular alundum No. 3 | 1620 |
| 98-alundum No. 1 | 1670 |
| 98-alundum No. 2 | 1680 |
| Black silicon carbide No. 1 | 2150 |
| Black silicon carbide No. 2 | 2050 |
| Green silicon carbide No. 1 | 2130 |
| Green silicon carbide No. 2 | 2140 |
| Molded boron carbide No. 1 | 2250 |
| Molded boron carbide No. 2 | 2260 |
| Molded boron carbide No. 3 | 2250 |
| Diamond | 5500 to 6950 |

*Diamond:*

Possibly the first attempts to associate indentation hardness numbers with the hardness of diamond were tests made under the direction of C. G. Peters in the Interferometry Section of the National Bureau of Standards. Using a load of 500 g., indentations were made in plane facets cut parallel to the cube and octahedron faces and to intermediate directions of diamond obtained from different mines in Africa and South America. A total of more than 150 indentations made in the diamonds had lengths ranging from 36 to 30 $\mu$ which gave a range of indentation hardness numbers from 5500 to 6950. This variation in length of the indentations may be caused by the degree of fracture of the surface produced by the indenter.

This effect was also found in brittle crystalline materials such as quartz, topaz, or sapphire.

From these indentation data it cannot be definitely stated that one diamond is harder than another. It is known, however, that a diamond cleaves or fractures more readily in certain directions than in others. Indenters cut with the point coinciding with one point of an octahedron crystal with the long diagonal parallel to one axis gave greatest resistance to fracture of the point.

Figure 2 shows indentations made in a surface cut parallel to the cube face of an octahedron crystal. The dark area is a cut produced by drawing the indenter along the surface. This treatment fractured the point of the indenter.

Figure 3 shows a group of the same indentations under higher magnification. Light fractures can be seen near the center of the indentations.

Tests made with properly prepared indenters showed no damage to the longitudinal edge after more than 50 indentations in a diamond.

Other natural minerals, as well as synthetic minerals, have been tested. Figure 4, a picture taken in the laboratory of the Elgin National Watch Co., shows an indentation on a watch sapphire endstone (thrust bearing) under a load of 1000 g. giving a Knoop number of 1837.

*Dentine and Enamel:*

The dental profession has been

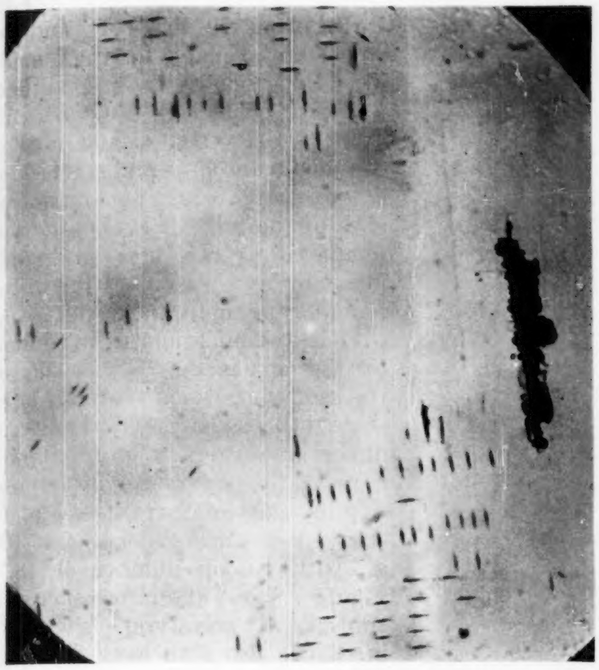

**Fig. 2.—Knoop Indentations in Diamond, Under Load of 500 g. (× 180).**

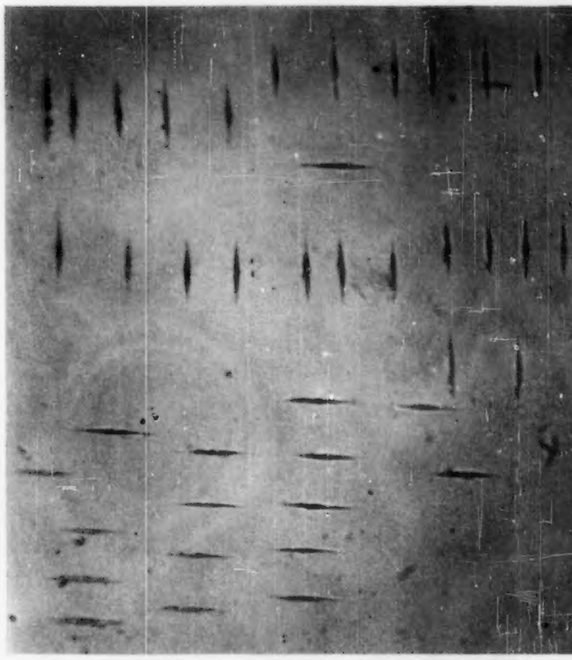

**Fig. 3.—Section from Fig. 2 (× 425).**

interested for years in studying the injury to enamel and dentine on human teeth from a dentifrice containing harsh abrasives, and at the National Bureau of Standards a very complete study of this and related problems was made by Wilmer Sander and Irl C. Schoenover (**7**). Indentations were made in enamel or dentine surfaces under definite load; these surfaces were then subjected to brushing tests, and, from a study of the measurements of the indentation made before and after the brushing tests, changes in surface structures were revealed.

Further studies of this nature are now being made and impressions are made on polished sections of freshly extracted teeth before brushing and then again after the test period. The Tukon tester and Knoop indenter have been used in this manner and much interesting information is being collected concerning the percentage loss or gain in hardness numbers.

Figure 5 shows the softening effect produced by a certain liquid on dentine. The smaller impressions were made before the specimen was subjected to test and the larger impression after the test period. The load applied was 300 g. and the magnification is 50 times. It can be observed that the long diagonal is easily measured and it has been found that the results are reproducible. These tests were made by Crosby F. Baker, Professor of Chemistry, Tufts College, Medford, Mass.

*Plastics:*

The hardness testing of plastics is now generally carried out on the Rockwell hardness tester (**8**). It must be remembered, however, that the Rockwell tester was designed for testing metals where the elastic recovery of the material is small in proportion to the total permanent indentation, whereas with plastics the reverse of this is true. Furthermore, the use of the Rockwell tester for plastics involves the factor of time control in application of minor and major loads because of creep and cold flow characteristics. The Knoop indenter and Tukon tester, with its automatic time control, offer a new approach to this problem which is becoming more and more important due to the application of plastics in bearings, tools, lenses, etc.

A series of samples of cellulose acetate butyrate molding composition, secured through the courtesy of the Tennessee Eastman Corp. of Kingsport, Tenn., was tested on the Tukon tester. These samples were of different grades and were made up in various thicknesses. Tests were run on the hardest and softest material, using three different loads on each of three different thicknesses, with the results shown in Table II. To study the variation of Knoop numbers on one material of different grades, a second set of tests was run and the results shown in Table III. All tests were made on samples ⅛ in. thick with a load

TABLE II.—KNOOP NUMBERS OBTAINED UNDER DIFFERENT LOADS ON DIFFERENT THICKNESSES OF CELLULOSE ACETATE BUTYRATE MOLDING COMPOSITION.

| Applied Load, g. | Knoop Hardness Numbers: ¼ in. Thick | ⅛ in. Thick | $\frac{1}{16}$ in. Thick |
|---|---|---|---|
| SPECIMEN 239 $S_6$ | | | |
| 50 | 1.8 | 1.9 | 1.9 |
| 100 | 1.9 | 1.9 | 2.0 |
| 300 | 1.9 | 1.9 | 1.9 |
| SPECIMEN 205 $H_4$ | | | |
| 50 | 9.2 | 9.0 | 9.1 |
| 100 | [illegible] | 8.8 | 8.8 |
| 300 | 9.5 | 8.5 | 8.6 |

TABLE III.—KNOOP NUMBERS ON DIFFERENT GRADES OF CELLULOSE ACETATE BUTYRATE MOLDING COMPOSITION.

| Grade | Knoop Hardness Numbers: From Long Diagonal | From Short Diagonal |
|---|---|---|
| 205$H_4$ | 8.8 | 13.3 |
| 205$H_2$ | 7.2 | 8.7 |
| 205$M_H$ | 6.2 | 7.4 |
| 205$M_S$ | 4.9 | 5.7 |
| 205$S_2$ | 4.3 | 4.7 |
| 205$S_4$ | 3.3 | 3.6 |
| 239$S_6$ | 1.9 | 2.2 |

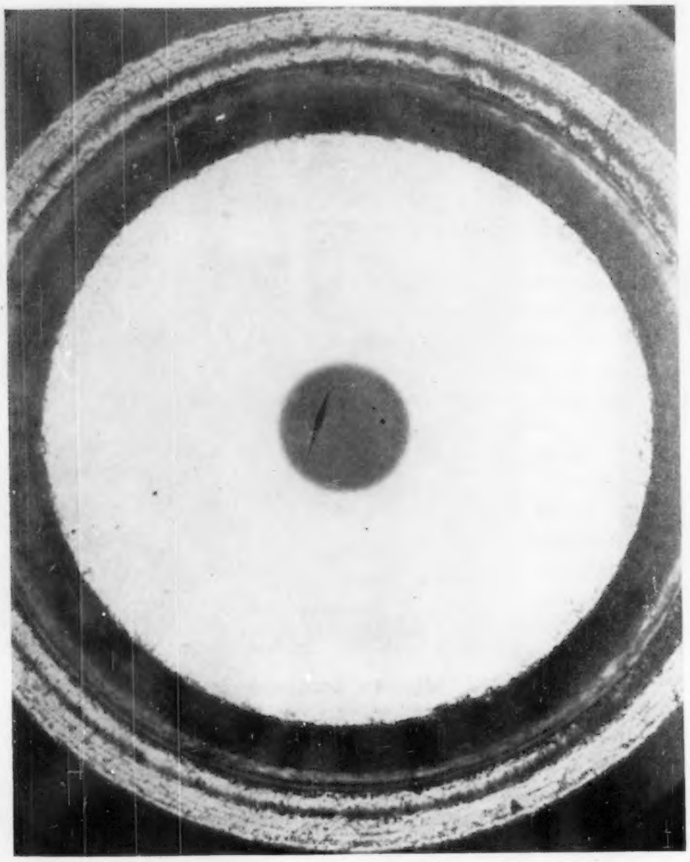

**Fig. 4.—Knoop Indentation in a Sapphire Endstone (Thrust Bearing), Under Load of 1000 g.; Knoop Number 1837 (× 100).**

of 100 g. In these tests, the recovered Knoop number as determined by measuring the width of the impression was also obtained and reported. The measurement of the width of impression is not a simple determination and requires considerable experience and the results may be influenced by the judgment of even a trained operator to a considerable extent.

Unfortunately these tests could not be made under temperature and humidity control. The temperature varied from 70 to 84 F. and no values are available for the humidity. Inasmuch as these conditions were not controlled, the values in Tables II and III should not be considered absolute, and this lack of control may account for any anomalies in the tables. Each test represents an average of several readings and in no case does the maximum or minimum for one grade overlap the minimum or maximum for the next grade. Rechecking of the same impression ten days later showed no appreciable change in dimension on this type of material.

Figure 6 shows a Knoop impression in transparent cellulose acetate sheet, $\frac{1}{16}$ in. thick under load of 300 g., with Knoop number of 18.1. Figure 7 shows the impression in a transparent polystyrene sheet, $\frac{1}{16}$ in. thick, also with load of 300 g. but having a Knoop number of 16.7.

*Glass:*

The testing of glass presents a very different problem from plastic testing. In glass we have a brittle material which would shatter under ordinary hardness testing penetrators and loads. A series of glasses, supplied by the Pittsburgh Plate Glass Co., was tested on the Tukon tester and Knoop indenter. In addition to the determination of the Knoop hardness number, an attempt was made to evaluate the brittleness of the glass by increasing the load until fracture occurred

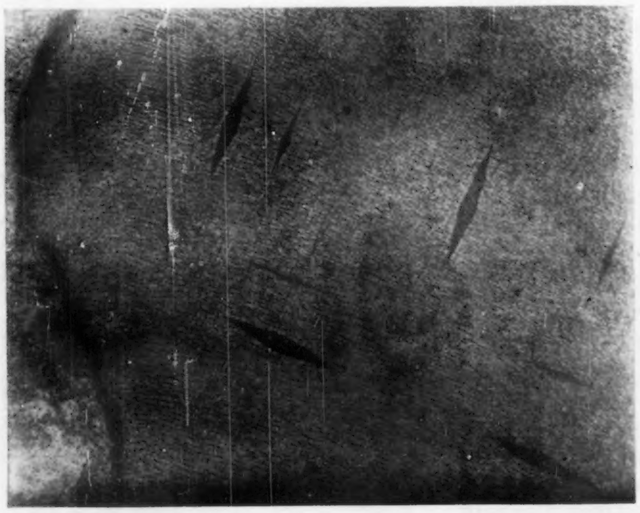

**Fig. 5.—Knoop Indentations in Dentine Under Load of 300 g. Larger Set of Impressions Made After Subjecting Tooth to Brushing Tests with a Certain Liquid (× 50).**

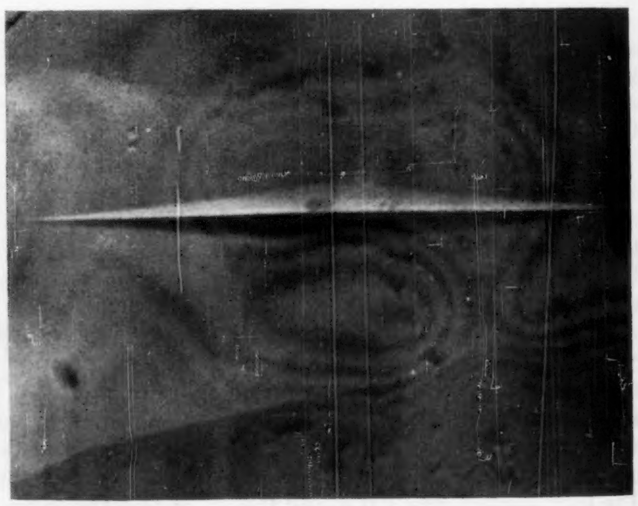

**Fig. 6.—Knoop Indentation in Transparent Cellulose Acetate Sheet, Under Load of 300 g.; Knoop Number 18.1 (× 160).**

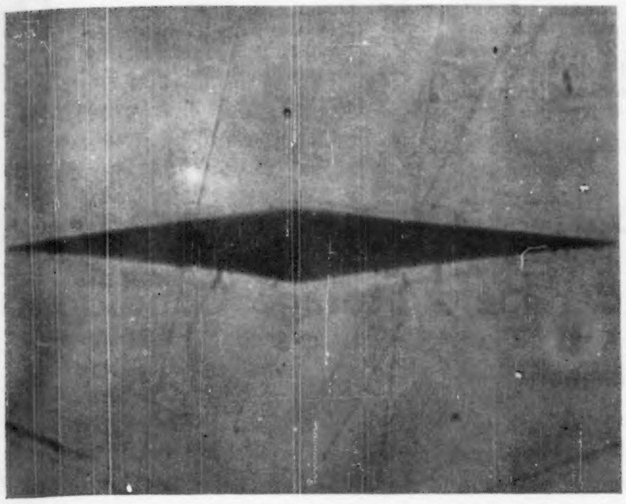

Fig. 7.—Knoop Indentation in Transparent Polystyrene Sheet, Under Load of 300 g.; Knoop Number 16.7 (× 160).

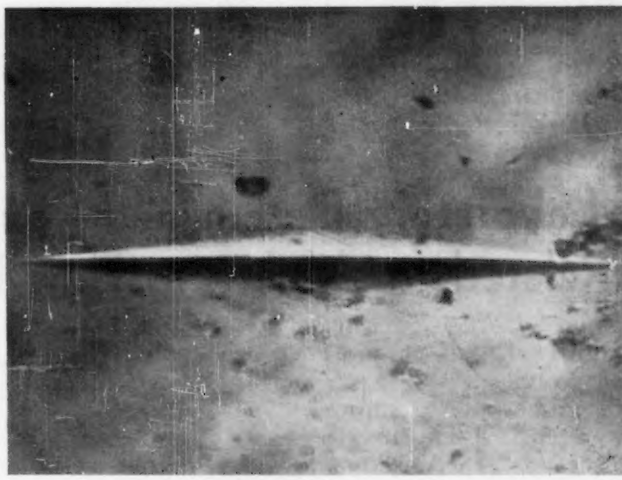

Fig. 8.—Knoop Indentation in Plate Glass Under Load of 1000 g.; Knoop Number 549 (× 650).

around the impressions. Table IV, gives the Knoop number for the various glasses as determined under a load of 500 g. Each value reported is the average of five tests and samples Nos. 1, 2, and 3; samples Nos. 4, 5, and 6; and samples Nos. 8 and 9, respectively, represent different samples of the same material.

TABLE IV.—KNOOP NUMBER OF VARIOUS GLASSES.

| Sample | Type of Glass | Knoop Number, 500-g. Load |
|---|---|---|
| No. 1..... | Soda-lime-silicate ($\frac{3}{32}$ in.) | 538 |
| No. 2..... | | 531 |
| No. 3..... | | 544 |
| No. 4..... | Soda-lime-silicate ($\frac{3}{16}$ in.) | 535 |
| No. 5..... | | 542 |
| No. 6..... | | 536 |
| No. 7..... | Soda-lime-silicate (¼ in.) | 518 |
| No. 8..... | Soda-lime-silicate (¼ in.) Heat treated | 510 |
| No. 9..... | | 527 |
| No. 10..... | Soda-lime-silicate | 528 |
| No. 11..... | Iron-soda-lime-silicate (with varying iron content) | 494 |
| No. 12..... | | 476 |
| No. 13..... | | 445 |
| No. 14..... | | 428 |
| No. 15..... | Soda-potash-lime-silicate | 540 |
| No. 16..... | Barium silicate | 546 |
| No. 17..... | Lead silicate (with varying lead content) | 436 |
| No. 18..... | | 396 |
| No. 19..... | | 373 |
| No. 20..... | Phosphate | 517 |

It will be noted that there is good agreement in Knoop numbers on these materials—and in fact good agreement in all samples of soda-lime-silicate glass when tested under this load, except sample No. 8 which is definitely softer (this same effect was not noticed in sample No. 9).

Particular attention is called to the decreasing Knoop number on samples Nos. 11 to 14 as the iron content is varied and samples Nos. 17 to 19 as the lead content is varied.

The hardest sample, No. 16, was subjected to tests with loads increasing from 100 g., and it was found to fracture slightly with a load of 200 g. On the other hand, the softest sample, No. 19, withstood a load of 1400 g. before fracture occurred. However, this test was not entirely conclusive as an occasional test on sample No. 16 could be made with a load of 1000 g. without fracture.

Figure 8 shows an impression made in $\frac{3}{16}$-in. thick plate glass under a load of 1000 g. with a Knoop number of 549.

*Necessary Precautions:*

There are definite limitations on the use of the Knoop indenter that should be mentioned. Samples must be properly prepared by lapping plane and must be free from scratches. The testing surface must be so supported that it is normal to the indenter. Tests cannot be made on rounded edges obtained in metallographic polishing.

The load at which the test has been made must always be reported, as high values are obtained when testing with light loads (D. R. Tate (9)). This effect is now receiving considerable attention and study.

Measurements of indentations should be made by experienced operators using optical equipment with the greatest magnification that will give the best defined outline of the indentation.

This paper is not presented as a comprehensive report on all material. Rather, here are presented data and illustrations of the results obtained with the Knoop indenter and Tukon tester on representative materials such as plastics, which are very soft (Knoop number of less than 2.0) and flow considerably, through medium hard material, such as glass, to extremely hard and brittle material, such as a diamond (Knoop number over 6000). Much work remains to be done and it is the hope of the author that this paper will stimulate the testing for hardness of nonmetallic materials.

## References


(1) Frederick Knoop, Chauncey G. Peters, and Walter B. Emerson, "A Sensitive Pyramidal-Diamond Tool for Indentation Measurements," Nat. Bureau Standards, *Research Paper RP 1220*, July, 1939.

(2) Vincent E. Lysaght, "A Microhardness Testing of Materials," *Engineering Materials and Production Methods*, (formerly *Metals and Alloys*), Vol. *22*, No. 4, October, 1945, p. 1079.

(3) Samuel R. Williams, "Hardness and Hardness Measurements," p. 321. Published by Am. Soc. Metals, Cleveland, 1942.

(4) *Ibid.*, p. 84.

(5) Richard Schneidewind, "Hardness of Chromium as Determined by the Vickers-Brinell, Bierbaum, and Mohs

Methods," *Transactions*, Am. Soc. for Steel Treating, Vol. 19, No. 2, December, 1931.

(6) Chauncey G. Peters, and Frederick Knoop, "Metals in Thin Layers—Their Microhardness," *Metals and Alloys*, September, 1940, p. 292.

(7) Wilmer Souder and Irl C. Schoenover, "Abrasion and Solution of Teeth," Nat. Bureau Standards, *Research Paper RP1563*, November, 1943.

(8) "Tentative Method of Test for Rockwell Hardness of Plastics and Electrical Insulating Materials," Am. Soc. Testing Mats., 1944 Book of Standards, Part III, p. 1651.

(9) Douglas R. Tate, "A Comparison of Microhardness Indentation Tests," *Transactions*, Am. Soc. Metals, Vol. 35, p. 374 (1945).

# Laboratory Determined Pour Points of Lubricating Oils as Related to Ability to Flow Under Field Storage Conditions

By J. J. Giammaria[1]

In Appendix I of the 1945 Report of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants[2] a method was proposed for determining "Maximum Pour Points of Lubricating Oils Containing Pour Point Depressants." In the closing paragraph of the 1945 Report of Subcommittee XVI on Cloud and Pour Test it was indicated that field testing was in progress and evaluation of the merits of the method would have to await completion of such field tests. It is the purpose of this paper to review the work of Subcommittee XVI with particular reference to the phenomenon known as pour point reversion.

For many oils the A.S.T.M. Standard Method of Test for Cloud and Pour Points (D 97 – 39)[3] is a satisfactory measure of the temperature at which the oils will pour or flow when stored and used in cold climates. However, in the case of oils containing so-called "natural pour point depressants" such as black oils, cylinder stocks, and non-distillate fuel oils, as well as those oils containing added manufactured pour point depressants, the phenomenon known as pour point reversion introduces a disturbing effect. This effect evidences itself by the fact that oils of the character mentioned may fail to flow at temperatures considerably above the pour point as determined by A.S.T.M. Method D 97. Some oils will flow at temperatures lower than those predicted by the standard method. The determining factor as to the degree of this irregular variation is the sequence and amount of temperature changes to which the oil has been subjected during storage.

That this phenomenon has long been recognized is clearly evident from a reference to the reports of Subcommittee XVI. In a tentative method published in 1921[4] the following occurs: "Oils having a viscosity greater than 600 sec., Saybolt Universal at 100 F., shall be allowed to stand in the test jar at a temperature of 60 to 85 F. for at least 5 hr. prior to making the test for pour point. A viscous oil which has been stored in a warm place is liable to show an abnormally low, fictitious pour point unless this precaution is observed." Since viscous oils in 1921 were largely residual stocks and therefore were those most likely to contain natural pour point depressants, the implication of this reference is significant, although it was written long before pour point depressants came into use.

In 1924, still some seven years before the introduction of commercial pour point depressants, Rather and Anderson[5] published a paper in which they showed that, in the case of eight samples of black oils and cylinder stocks, the highest pour test was obtained if the sample was held in the laboratory at room temperature for 24 hr. before testing and then heated to 115 F. It was also observed that a much lower pour point was obtained if the sample was heated to approximately 220 F. before cooling for the determination of the pour test. These two heat treatments are still items in A.S.T.M. Method D 97.

In 1931[6] the work of Rather and Anderson was extended to fifteen more oils. Of these, twelve were found to give the highest pour points when heated to 115 F. but three were quite anomalous and gave pour points 10 to 25 F. higher when heated to some other temperature in the range of 100 to 135 F. In 1932[7] Moore and Beard published a paper on a microscopic study of four such anomalous oils and showed that the temperature of preheating required to establish the conditions for the "maximum pour point" was that temperature at which the wax crystal aggregates just disappeared when examined on a heated microscope slide. Higher or lower preheating temperatures gave lower pour points when the oil was cooled.

In 1934, three years after the introduction of commercial pour point depressants, the method was altered to provide for a series of cooling baths to permit slower and more uniform cooling[8] as it was recognized that the previous cooling rate was

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[2] Report of Committee D-2 on Petroleum Products and Lubricants, *Proceedings*, Am. Soc. Testing Mats., Vol. 45, p. 228 (1945).

[3] 1944 Book of A.S.T.M. Standards, Part III, p. 115.

[4] Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 21 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 674 (1921); also 1921 Book of A.S.T.M. Tentative Standards, p. 277.

[5] J. B. Rather and H. M. Anderson, "A Proposed Modification of the A.S.T.M. Pour Test Applicable to Those Oils Which Give Erratic Results by the Present Method," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 553 (1924).

[6] Report of Subcommittee XVI on Cloud and Pour Test, *Ibid.*, Vol. 31, Part I, p. 468 (1931).

[7] R. W. Moore and L. C. Beard, Jr., "A Microscopic Study of Certain Oils Which Show the Phenomenon of High and Low Pour Points," *Ibid.*, Vol. 32, Part I, p. 402 (1932).

more rapid than normally occurs during the commercial storage of oils. This slower cooling rate favored pour point depressants.

During the winter of 1937–1938 wide temperature fluctuations occurred in many regions and many companies experienced the embarrassing fact that their S.A.E. 10 grade oils would not pour from their containers in service stations even though these oils originally had A.S.T.M. pour points well below the temperature at which they failed to pour. This occurrence as well as the desire to protect our Armed Forces from such incidents started a series of investigations to find a laboratory test which would more accurately predict the temperature at which an oil would flow regardless of its previous thermal history. Two publications in this respect are worthy of note. One by Hodges and Boehm[9] proposed a test in which the oil was taken through a succession of temperature cycles. Starting with a cycle of, say, −30 to +30 F., the temperature was raised and lowered on a regular cycle dropping the top temperature 10 F. in each succeeding cycle until the solidifying temperature was found. The stable pour point was reported as 5 F. above the highest temperature at which the sample was found solid during the test. The test required about one week to run and used elaborate and expensive equipment. This test will be referred to again in this paper and will be designated as "S.O.N.J. Type V Test." The other publication by Henderson and Annable[10] proposed two tests, one providing a slow time-temperature cycle, the other a rapid cycle. The oil had to pass both cycles to be considered satisfactory. Both of the above papers, as well as one by Bondi,[11] give information on the effects of wax content, melting points of the waxes present, percentage of pour point depressant, character of the oil, etc., on this phenomenon. A review of the above papers readily discloses that the solidification of lubricating oils is an exceedingly complex phenomenon and, despite the vast amount of work done, the controlling factors are not definitely known nor is their influence readily predictable.

At this point, it might be well to include a word on the practical significance of the pour test. Oils of high pour test have sometimes been said to be the cause for slow or non-starting of motors in cold weather. This is not true. The following quotations from the A.S.T.M. Symposium on Motor Lubricants[12] are pertinent: "It is this viscosity effect which has so often led to the erroneous conclusion that high pour point oils have high break-away torques. The viscosity of the oil at the starting temperature, and more particularly that of the oil or diluted oil on the cylinder walls where areas and speeds are large, is the controlling factor so far as starting is concerned" and again, "The flow of a lubricating oil at low temperatures is dependent upon the viscosity as obtained by an extrapolation on the A.S.T.M. viscosity-temperature chart and the yield value. The pour point is the temperature at which the yield point approaches zero. Where we have high rates of shear and high shearing stresses, the effect of pour point is small, as in the cranking speed of a cold motor. Where the shearing stresses are low as in the case of the rate of feed to the pump under gravity, the pour point becomes important and will affect the time required for the initial flow of oil to the bearings." The above quotations indicate that pour point is most significant in the matter of flow at low rates of shear as, for example, in pouring from containers or in providing feed to pumps or oil distributing mechanisms which operate under a small head of oil. It should be remembered that the force initiating flow, under the conditions of the pour point determination in the A.S.T.M. test jar, is less than a 2-in. head.

For several years Subcommittee XVI has worked intensively toward the development of a method that would predict the pour points of S.A.E. 10 and 20 grade motor oils containing pour point depressants during winter storage. It was a further objective of the subcommittee to develop a method which would utilize simple and inexpensive equipment and which would permit determinations to be completed in the average working day. As was stated in the first part of this paper, such a method was proposed and has been published "For Information Only."

The following describes the investigation of the laboratory test methods with particular emphasis on their correlation with field performance as conducted by a sub-subcommittee of A.S.T.M. Subcommittee XVI.

### Testing Procedures

*Laboratory Testing:*

The proposed method as described in the 1945 Report of Committee D-2 was applied to 19 carefully selected oils in three different laboratories. The maximum pour points listed in Table I are averages of the values reported by the three laboratories as shown in the 1945 report. The A.S.T.M. cloud and pour points listed are average values of seven different laboratories and were also taken from the above report. Attention is called to oil sample No. 8 in Table I which showed a maximum pour point of 0 F. or above. When such indeterminate values are obtained, that is when both sample and duplicate are solid at the prescribed temperature of observation on the third cycle of the test, a fourth cycle should be added. Such cases are exceptional, most oils giving definite maximum pour points after three cycles and, in general, oils of good pour point stability show no further reversion after the third cycle.

The S.O.N.J. Type V test referred to above was also applied to the 19 oils and the values listed in Table I are single determinations as submitted by the S.O.N.J. laboratory.

*Field Testing:*

A small sub-subcommittee of Subcommittee XVI on the correlation of laboratory test methods with field storage studied the performance of the 19 oils listed in

[8] Report of Committee D-2 on Petroleum Products and Lubricants, *Ibid.*, Vol. 34, Part I, pp. 431–432.

[9] C. E. Hodges and A. B. Boehm, "Pour-Point Stability of Treated Oils Under Winter Storage Conditions," *Oil and Gas Journal*, Vol. 42, No. 1, June 24, 1943, p. 103.

[10] L. M. Henderson and W. G. Annable, "Pour Point Stability of Lubricating Oils," *Ibid.*, Vol. 42, September 9, 1943, pp. 54–59.

[11] A. Bondi, "Physical Properties of Lubricating Oils at Low Temperatures," *Petroleum Refiner*, Vol. 22, No. 9, September, 1943, pp. 287–294.

[12] "Symposium on Motor Lubricants," Am. Soc. Testing Mats., March, 1933, p. 45–47. (Issued as separate publication.)

TABLE I.—CORRELATION OF LABORATORY AND FIELD TESTS ON SUBCOMMITTEE XVI OILS.
(Results are in Degrees Fahrenheit)

| Oil Sample | Socony-Vacuum Oil Co., Inc. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Casper (1944) | | Casper (1945) | | Olean (1945) | | Milwaukee (1945) | | St. Paul (1945) | |
| | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid |
| HC-1 | .... | .. | +19 | 16 | +20 | 44 | +19 | 16 | +19 | 30 |
| HC-2 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| HC-3 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| IC-4 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| IC-5 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| LC-6 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| 7 | <−11 | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| 8 | .... | .. | +12 | 5 | +22 | 38 | +11 | 5 | +19 | 46 |
| 9 | <−11 | .. | <−5 | .. | −2 | 3 | −11 | 1 | −5 | 2 |
| 10 | <−11 | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| 11 | +11 | 1 | +4 | 1 | +12 | 13 | −1 | 5 | −5 | 3 |
| 12 | .... | .. | +18 | 8 | +18 | 24 | +14 | 16 | +16 | 22 |
| 13 | .... | .. | <−5 | .. | −13 | 1 | <−11 | .. | <−11 | .. |
| 14 | .... | .. | <−5 | .. | +5 | 4 | −3 | 3 | +1 | 2 |
| 15 | .... | .. | +19 | 11 | +15 | 20 | +11 | 10 | +15 | 15 |
| 16 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| 17 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| 18 | .... | .. | −6 | 1 | <−19 | .. | −3 | 1 | <−11 | .. |
| HC-12 | .... | .. | <−5 | .. | <−19 | .. | <−11 | .. | <−11 | .. |
| Minimum temperature during field tests | −11 | | −5 | | −19 | | −11 | | −11 | |

| Oil Sample | Standard Oil Co. of New Jersey | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Warren (1944) | | Warren (1945) | | Minneapolis (1944) | | Minneapolis (1945) | |
| | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid |
| HC-1 | +19 | 38 | +23 | 32 | +18 | 27 | +22 | 54 |
| HC-2 | +13 | 7 | −13 | 1 | +16 | 6 | <−8 | .. |
| HC-3 | .... | .. | <−13 | .. | .... | .. | <−8 | .. |
| IC-4 | <−8 | .. | <−13 | .. | −2 | 1 | <−8 | .. |
| IC-5 | .... | .. | <−13 | .. | .... | .. | <−8 | .. |
| LC-6 | <−8 | .. | −13 | 1 | <−11 | .. | <−8 | .. |
| 7 | .... | .. | <−13 | .. | .... | .. | <−8 | .. |
| 8 | .... | .. | +11 | 2 | .... | .. | +18 | 13 |
| 9 | .... | .. | 0 | 5 | .... | .. | +4 | 7 |
| 10 | .... | .. | −12 | 1 | .... | .. | +4 | 5 |
| 11 | .... | .. | +12 | 14 | .... | .. | +6 | 5 |
| 12 | .... | .. | +16 | 23 | .... | .. | +19 | 35 |
| 13 | .... | .. | −1 | 2 | .... | .. | −8 | 1 |
| 14 | .... | .. | −1 | 2 | .... | .. | +6 | 10 |
| 15 | .... | .. | +18 | 12 | .... | .. | +16 | 22 |
| 16 | .... | .. | <−13 | .. | .... | .. | <−8 | .. |
| 17 | .... | .. | <−13 | .. | .... | .. | <−8 | .. |
| 18 | .... | .. | <−13 | .. | .... | .. | <−8 | .. |
| HC-12 | <−8 | .. | −13 | 1 | <−11 | .. | <−8 | .. |
| Minimum temperature during field tests | −8 | | −13 | | −11 | | −8 | |

| Oil Sample | The Pure Oil Co. | | | | | | | | Grand Total Times Solid | Stable Pour Point from Field Data | Maximum Pour Point by Laboratory Test | S.O.N.J.* Type V Test | A.S.T.M. Cloud Point | A.S.T.M. Pour Point |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minneapolis (1945 Storage) | | Minneapolis (1945 Display) | | Midland (1945) | | Mundelein (1945) | | | | | | | |
| | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | Maximum Solid Point | Number Times Solid | | | | | | |
| HC-1 | +22 | 67 | +20 | 30 | +26 | 53 | +15 | 13 | 420 | +26 | +15 | +20 | 32 | −25 |
| HC-2 | <−9 | .. | <−10 | .. | <−2 | .. | <−14 | .. | 14 | +16 | +10 | −10 | 32 | −15 |
| HC-3 | <−9 | .. | −10 | 1 | +20 | 2 | <−14 | .. | 3 | +20 | +15 | <−25 | 32 | −20 |
| IC-4 | −4 | 2 | <−10 | .. | <−2 | .. | <−14 | .. | 3 | −2 | 0 | 0 | 18 | −20 |
| IC-5 | <−9 | .. | <−10 | .. | <−2 | .. | <−14 | .. | 0 | <−19 | −15 | −5 | 12 | −30 |
| LC-6 | <−9 | .. | <−10 | .. | +5 | 1 | <−14 | .. | 2 | +5 | −10 | −5 | 8 | −20 |
| 7 | <−9 | .. | −10 | 1 | +5 | 1 | <−14 | .. | 2 | +5 | −25 | −15 | 14 | −25 |
| 8 | +9 | 23 | +26 | 54 | +7 | 8 | +7 | 5 | 199 | +26 | 0 or above | <−25 | 44 | −30 |
| 9 | +9 | 8 | −2 | 4 | +2 | 1 | +3 | 8 | 39 | +9 | +15 | +10 | 22 | −10 |
| 10 | +9 | 6 | −2 | 2 | <−2 | .. | −8 | 2 | 16 | +9 | +20 | +10 | 22 | −10 |
| 11 | +12 | 19 | +6 | 13 | <−2 | .. | +14 | 14 | 88 | +14 | +15 | +15 | 22 | −10 |
| 12 | +17 | 49 | +11 | 26 | +26 | 19 | +15 | 17 | 239 | +26 | +15 | +10 | 28 | −25 |
| 13 | −8 | 1 | −10 | 1 | <−2 | .. | −10 | 1 | 7 | −1 | −15 | −20 | 18 | −25 |
| 14 | +9 | 9 | +1 | 4 | <−2 | .. | 0 | 5 | 39 | +9 | −20 | <−25 | 24 | −30 |
| 15 | +16 | 39 | +16 | 22 | +23 | 15 | +10 | 11 | 177 | +23 | +15 | 0 | 32 | −20 |
| 16 | −8 | 1 | −10 | 1 | <−2 | .. | <−14 | .. | 2 | −8 | −20 | <−25 | 16 | −25 |
| 17 | <−9 | .. | <−10 | .. | <−2 | .. | <−14 | .. | 0 | <−19 | +10 | −5 | 20 | −25 |
| 18 | <−9 | .. | <−10 | .. | +5 | 3 | 0 | 5 | 10 | +5 | +5 | −10 | 30 | −25 |
| HC-12 | <−9 | .. | <−10 | .. | <−2 | .. | <−14 | | 1 | −13 | +25 | −5 | 32 | +15 |
| Minimum temperature during field tests | −9 | | −10 | | −2 | | −14 | | ... | .... | .... | .... | .. | .. |

Table I at eight different stations during the winter of 1944–1945.

Samples were stored at Casper, Wyo.; Olean, N. Y.; Milwaukee, Wis.; St. Paul, Minn.; Warren, Pa.; Minneapolis, Minn.; Midland, Mich.; and Mundelein, Ill. Three sets of samples were exposed at Minneapolis, two in storage and one on display. Display samples differed from storage samples in that they were racked in the weather during the day including sunlight and snow but placed in an unheated room at night. Tests were also conducted on nine of the oils during the winter of 1943–1944.

The field test samples were submitted in tall form 4-oz. bottles filled to the correct height to conform with pour point determination by A.S.T.M. Method D 97. The bottles were sealed at all times. The samples were placed on an open shelf with sufficient space between them for free circulation of air and exposed to full atmospheric temperature fluctuations although protected from direct sunlight. Observations were made daily in the early morning and late afternoon and were performed in accordance with A.S.T.M. Method D 97 for pour point determination. Thus, the sample bottle was lifted momentarily and returned to place as soon as any movement of the oil was discerned. If no movement was observed, on holding the bottle in a horizontal position for not more than 5 sec., the sample was reported as solid. The prevailing temperature recorded on a thermometer located with the samples at the time of observation was reported as well as hourly temperatures.

The maximum solid point observed for each sample and the number of times it solidified during the field test are listed under the individual stations as shown in Table I. The field stable pour points listed represent the highest solid point observed for each sample at any of the stations. The highest solid point was used as the stable pour point since field experience has shown that, in some instances, oils stored in a 4-oz. bottle solidified at temperatures at least 5 F. higher than when stored in larger containers such as quarts or drums. On this basis, the addition of 5 F. to the

solid point to denote the stable pour point was not justified.

### Correlation and Discussion of Test Data

The results of all the field and laboratory tests on the 19 committee oils are summarized in Table I. In correlating field stable pour points with maximum pour points obtained by the proposed laboratory test approximately a 10 F. spread was allowed based on the degree of reproducibility of the test as claimed in Appendix I of the 1945 Report of Subcommittee XVI. Herein it was stated that individual results of the test for maximum pour point on the same oil in any one laboratory may vary by 5 F. and in different laboratories by 10 F.

Comparing the field stable pour points with the laboratory maximum pour points it is seen that good to fair agreement occurred in the case of 12 of the 19 oils, namely, oils HC-1, HC-2, HC-3, IC-4, IC-5, 9, 10, 11, 12, 15, 16, and 18. This represents 63 per cent correlation within an approximate 10 F. range. In the case of several of the oils a high field maximum solid point was only observed once or twice at one particular station, the remaining stations reporting excellent stability. For example, HC-3 solidified twice at 20 F. at Midland, IC-4 once at −2 F. at Minneapolis (1944) and twice at −4 F. at Minneapolis (1945), LC-6 once at 5 F. at Midland and 7 once at 5 F. at Midland. If the results at these stations are ruled out and maximum solid points are based on the remaining stations it is seen that oils HC-3 and IC-4 are no longer in agreement with laboratory maximum pour points. On the other hand, if oils LC-6 and 7 are similarly treated the field and laboratory results are in agreement. Thus the degree of correlation still remains the same.

In comparing S.O.N.J. Type V results with field stable pour points good agreement occurred in the case of 7 out of the 19 oils including HC-1, IC-4, LC-6, 9, 10, 11, and HC-12 or 37 per cent correlation within an approximate 10 F. range. If oils HC-3, IC-4, LC-6, and 7 are treated as above, fair agreement is shown with HC-3, LC-6, and 7 but poor agreement with IC-4. This would increase the over-all agreement to 8 out of 19 oils or about 42 per cent.

A comparison of the A.S.T.M. pour points as determined by Method D 97 with field stable pour points emphasizes the well-recognized failure of this test to predict pour point stability in lighter oils. It is seen that agreement occurred only with oils IC-5 and 17 or two out of 19 oils representing about 10 per cent correlation. The results indicate Method D 97 to be decidedly partial to oils containing manufactured pour point depressants as shown by the fact that low A.S.T.M. pour points were obtained in all cases except HC-12. The proposed method for determining maximum pour points definitely overcomes this partiality and furnishes much more reliable results than the present A.S.T.M. Method D 97 when applied to oils which are susceptible to pour point reversion.

In the case of the seven oils showing poor agreement between the field and laboratory maximum pour points, the latter rated oils LC-6, 7, 8, 13, and 14 as being of greater pour point stability than the field data actually showed if the absolute maximum field solid points are considered instead of the over-all field results. It should be pointed out that the value of 0 F. or above for sample No. 8 gives a definite indication of pour point instability and that further cycling, as previously mentioned, would probably give a high maximum pour point in closer agreement with the field stable pour point. In the case of oils 17 and HC-12 the laboratory maximum pour points indicated inferior pour point stability than shown by the field data. Although the latter two cases might be considered as errors on the safe side, the laboratory method does these oils some injustice. However, this is bound to happen in a test predicting anomalous characteristics of an oil. Actually, as mentioned above, the proposed method cuts down the injustice done by the present A.S.T.M. Method D 97 to a small percentage. In this connection it is seen that the test is quite consistent in predicting the behavior of very poor oils such as shown by the test data on oils HC-1, 8, 9, 11, 12, and 15. In other words, the test will usually serve as a warning in the case of potential complaint oils but such a warning is not consistently justified for all oils.

The S.O.N.J. Type V test showed the objectionable tendency of rating oils more stable than indicated by the field data as shown in the case of oils HC-2, HC-3, 7, 8, 13, 14, 15, 16, and 18 which all exhibited much lower stable pour points by the Type V test than were obtained in the field.

A correlation of field stable pour points with laboratory stable pour points as determined by the pro-

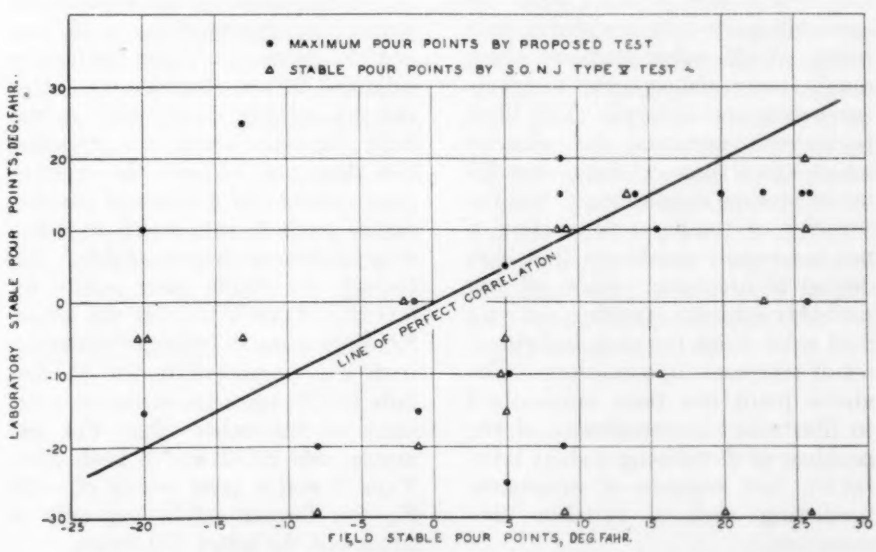


**Fig. 1.—Comparison of Stable Pour Points by Laboratory and Field Tests.**

posed test and the Type V test is shown graphically in Fig. 1. From this plot, a more accurate degree of correlation of each laboratory test with field results within various exact temperature ranges may be determined as shown in Table II.

TABLE II.—CORRELATION OF FIELD AND LABORATORY RESULTS WITHIN VARIOUS TEMPERATURE RANGES.

| Temperature Range of Correlation, deg. Fahr. | Number of Oils Within Temperature Range Specified | |
|---|---|---|
| | By Laboratory Maximum Pour Points | By S.O.N.J. Type V Stable Pour Points |
| Within 5 | 5 | 4 |
| Within 10 | 8 | 7 |
| Within 15 | 14 | 10 |
| Within 20 | 14 | 14 |
| Within 30 | 18 | 16 |
| Within 60 (Total) | 19 | 19 |

The above results show 26 per cent agreement within 5 F., 42 per cent within 10 F., and 74 per cent within 15 F. for the proposed laboratory test. The S.O.N.J. Type V test results show 21 per cent agreement within 5 F., 37 per cent within 10 F., and 53 per cent within 15 F.

The correlation of laboratory maximum pour points with the absolute maximum field solid points as described above may appear to be a rather severe procedure. However, the anomalous behavior of certain oils under varying field conditions is well known so that isolated cases of a high degree of pour point reversion cannot be ignored. For example, it is seen that some of the highest field solid points were obtained at Midland where a minimum atmospheric temperature of only −2 F. was reported while the same oils gave very low stable pour points at the other stations where much lower atmospheric temperatures were encountered. This illustrates the variation in behavior which an oil may exhibit under different storage conditions. Thus the severity of temperature cycling is not necessarily conducive to a high degree of reversion. Each oil will probably exhibit a specific maximum field solid point for each individual set of temperature conditions. The above point has been emphasized to illustrate the complexity of the problem of developing a short laboratory test capable of accurately predicting such a variable phenomenon.

The results shown in Table I present an unfavorable picture of the pour point reversion problem when viewed from the marketers standpoint. However, the results are not necessarily typical of S.A.E. 10 grade oils in general. It should be pointed out that the 19 oils used were carefully chosen to represent oils of good, borderline, and bad pour point stability, as determined by previous field experience, in order to furnish a reliable basis for evaluation of the laboratory test methods. Since emphasis was placed on the latter two types of oils, the percentage of bad oils is higher than would normally be expected.

## Limitation of the Proposed Laboratory Test

Although, as pointed out above, the proposed method has some merit in that it generally predicts the behavior of very unstable oils, a further examination of the test data reveals a rather serious limitation.

The laboratory maximum pour points on oils HC-1 and HC-3 are the same, +15 F. However, their over-all field performance is quite different, HC-1 solidifying 420 times but HC-3 only 3 times. Thus, based on the maximum pour points, the two oils are rated equally poor, although the frequency of solidification in the field definitely proves HC-3 to be an oil of much greater pour point stability. The failure of the laboratory test to take cognizance of this frequency factor is further illustrated with oils 12 and 17. Here again the maximum pour points are comparable, +15 and +10 F., respectively, yet the former solidified 239 times while the latter did not solidify at any time in the field. In other words, the proposed test does not indicate the relative pour stability of a series of oils but rather tends to rate an oil as either very stable or very unstable. Although the stable pour points by S.O.N.J. Type V test on the above oils show a much better relationship with the frequency factor, it also fails in the opposite direction with some of the other oils. For example, oils HC-3 and 8 both gave Type V stable pour points of −25 F., the former solidifying only 3 times but the latter 199 times.

The limitation of the test described above will probably be inherent in any short laboratory test but this point cannot be overlooked since the reliable prediction of the phenomenon of pour point reversion is a matter of the utmost importance both to the users and manufacturers of pour point depressants.

## Conclusions

The following may be concluded from the results of the present investigation.

1. The proposed laboratory test for determining maximum pour points has the advantage of utilizing present A.S.T.M. equipment for pour point determination and of being performed in 6 to 8 hr., both of which were definite objectives of the subcommittee. The S.O.N.J. Type V Test, on the other hand, requires about one week to run and utilizes elaborate and expensive equipment.

2. The proposed test represents a vast improvement over the present A.S.T.M. Method D 97 as a means of predicting pour point stability and is more reliable than any test published heretofore based on a correlation with available field test data. This correlation, based on an approximate 10 F. agreement between field and laboratory results, shows about 10 per cent agreement with A.S.T.M. Method D 97, 63 per cent with the proposed test, and 37 per cent with the Type V Test.

3. The proposed test is quite consistent in giving warning in the case of very unstable or potential complaint oils, but such warning is not consistently justified for all oils.

4. The test has a definite limitation in that it fails to indicate the relative field performance of a series of oils when maximum pour points are compared with the frequency of solidification in the field. That is, an oil may be 300 times better than another in the field based on the frequency factor, yet the laboratory test tends to rate them equally poor. The S.O.N.J. Type V test shows a somewhat better relationship between stable pour point determinations and the frequency of solidification in the field.

In fairness to the proposed test it should be pointed out that the above conclusions are based on rather

limited field testing. Past experience has shown that a severe winter resulting in abnormal field complaints may only occur once in several years. It is possible that continued field testing of the 19 reference oils over a period of years might result in a higher degree of correlation between the proposed test and field performance. Although the proposed test represents notable progress toward the development of a short pour point reversion test and is more reliable than any test yet published, the present test data certainly indicate that the problem is not completely solved. Obviously the conclusive merits and faults of the proposed test will only be established through extensive and varied application. Meanwhile, work is continuing both on laboratory and field testing.

*Acknowledgment:*

This paper was prepared at the request of the chairman of the A.S.T.M. Subcommittee XVI and on behalf of the subcommittee. Particular acknowledgment is made of the assistance of the following in collecting data or in the preparation of the paper: W. G. Annable, L. C. Beard, Jr., H. W. Faust, P. M. Goodloe, J. G. McNab, M. M. Sadlon, and W. Van Horne.

## Discussion of Paper on Small-Scale Tests for Fire-Retardant Wood[1]

*Submitted by A. J. Steiner:*[2]

Mr. Gottschalk's treatise of the variations in results obtained by the fire tube and crib tests and suggestions for corrections seems to be a continuation of discussions which have extended over many years. My experience with these test methods indicated that they produce test results within practical limits, but that the cause for discussion seems to develop because producers of treated lumber and specification writers desire to use these tests as criteria of acceptance. Fundamentally, these tests provide desirable information when used for plant control and study of treatment, but they do not provide all the information needed for the acceptability of a specific treatment for lumber for specific uses.

Thus far, very little work has been done to determine whether fireproofed lumber will provide the desired effect when exposed to fire under field conditions. This is needed as has been the case for building materials such as, for example, steel, brick, asphalt, and others. The acceptance of these materials has been developed by large-scale tests and field experience which eventually resulted in specifications such as A.S.T.M. Specifications (A 7)[3] for Steel for Bridges and Buildings, (C 62) for Building Brick,[4] and for Asphalt for Dampproofing and Waterproofing (D 449).[5]

Treated lumber for columns, walls, and doors should be first tested according to the method prescribed by the A.S.T.M. Committee C-5 on Fire Tests of Materials and Construction, which evaluates the fire resistance of these assemblies in terms of time. The specifications for such assemblies include the materials used, as well as the method of construction. The fire tube and crib tests can be used in determining the treatment of the lumber, but these tests will only develop one of the properties and others such as chemicals used, strength of the solution, and depth of penetration will be needed to identify the treatment.

If treated lumber is intended to prevent spread of fire on the surface of such material, then a test such as described in ASTM BULLETIN No. 121, March, 1943, should be used for purposes of classification and again, the fire tube and crib tests are effective instruments to establish the properties of the treated lumber in combination with other tests such as referred to above. In the large-scale test conducted by the above method, it has been shown that different species of lumber with the same chemicals, concentrations, and depth of penetration give considerably different results because of the character of cracks developed by large exposed surfaces and the variations in the character of the char; also, the release of resins due to temperatures developed during the fire exposure. These characteristics are not observed in the conduct of small-scale tests such as the fire tube and crib tests.

In general, specimens used in the fire tube and crib tests are confined to those having been treated throughout their cross-sections, while the large portion of treated lumber is only treated to a partial depth. The data developed by fire tube and crib tests do not take into consideration partial-depth treatment and this is very important when considering lumber for building construction.

[1] F. W. Gottschalk, "Some Factors in the Interpretation of Small-Scale Tests for Fire-Retardant Wood," ASTM BULLETIN No. 136, October, 1945, p. 40.

[2] Protection Engineer, Underwriters' Laboratories, Inc., Chicago, Ill.

[3] 1944 Book of A.S.T.M. Standards, Part I, p. 1993.

[4] *Ibid.*, Part II, p. 162.

[5] *Ibid.*, Part II, p. 1413.

ASTM Bulletin

JANUARY 1946

NO. 138

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PHILADELPHIA 2, PENNA.

## Stoichiometrical ?

THE question mark in the above caption is perhaps quite logical for, let us say, three-quarters of the membership and committee members of the Society. Undoubtedly the balance, who might be chemists or chemical engineers concerned with analytical procedures, would think the term not at all unusual. For the information of those where the question mark applies, this term relates to the art or process of calculating the combining weights of the elements; it has to do with the laws of chemical combination.

If instead of this term we had used the caption "Widmanstätten Structure" perhaps many of the chemists and chemical engineers might have assumed that we were referring to some building in Germany. Actually this is a type of grain structure or crystal appearance occurring in steel and well known to the metallurgist or metallographer.

Probably a very small percentage of our membership ever heard of "para-tertiary-octyl-phenoxyethoxyethyl-dimethyl-benzyl-ammonium chloride monohydrate" and the only reason we know about it is that it appears as the chemical name for an antiseptic solution which doesn't burn like iodine for example, when used on cuts, etc., and apparently it does kill the bugs.

Actually the term "stoichiometrical" is used in an accompanying BULLETIN article which describes some of the work of Committee E-3 on Chemical Analysis of Metals, particularly the new book on A.S.T.M. Methods of Chemical Analysis which will be published late this Spring. The number of authorities in the field of chemical analysis who are responsible for promulgating and revising the A.S.T.M. analytical methods for metals is a relatively small group, Committee E-3 showing a membership of some 80. Nevertheless their work is of great importance; it is recognized as widely as any A.S.T.M. technical developments; and whenever referee methods of analysis in the metals field are employed they are pretty sure to be the A.S.T.M. standards. The work of this group is of vital importance to the ferrous and nonferrous industry.

The accompanying article on the greatly revised new book indicates the intense activity which has been going on in Committee E-3 and the results are bound to be of widespread importance and value.

There is a common expression that "it takes all kinds of people to make this world." It takes all kinds of technologists and men concerned with materials to carry on the A.S.T.M. work and it is a *rara avis* who can discuss intelligently all that's going on in the Society's technical committees. Nevertheless each of the standardization or research projects are of importance to American industry.

In an accompanying significant statement by President Townsend addressed especially to new members reference is made to the desirability both from the Society's standpoint and the particular individual's welfare of becoming interested in technical committee work. Only by a continuing influx of new ideas and new energy can the work of any organization like A.S.T.M. make progress. But it is a distinct responsibility to apply for service on the technical committees, in view of the importance of the work, and one is immediately put on his mettle because around him are many of the country's leading authorities in the particular problem concerned.

It is encouraging and, in fact, inspiring to note the number of newer members who are constantly bringing new blood to the various A.S.T.M. groups.

## Progress on Headquarters Building

WHILE it is probable that no contractor or engineer ever makes as much progress in a construction or renovating project as the owner would wish, and that situation holds with respect to the new Headquarters Building which is being expanded and renovated, nevertheless much progress has been made. Inclement weather, in fact very severe cold for the Philadelphia area, has prevented outside work on quite a number of days, but interior work has been going ahead. The architect and those concerned have been proceeding with arrangements for the installation of the passenger elevator, for the considerable modifications in the plumbing and electrical systems and such matters. It is planned to use several smaller air conditioning units throughout the building which will be used to distribute heat and in the summertime take some of the peaks off the famed Philadelphia high temperatures and humidity.

It is not possible to set any exact date, even the week, when the Headquarters Staff will be able to start functioning at 1916 Race Street but general moving day may come some time in late April.

*A.S.T.M. Building Fund:*

A number of additional subscriptions to the Building Fund have been received since the publication of the December BULLETIN in which was published the first extensive list of Company, Association, and Individual contributors. A list of additional subscribers up to January 16 follows:

COMPANIES:
Acme Steel Co.
Battenfeld Grease & Oil Corp.
Bemis Bros. Bag Co.
A. M. Byers Co.
Chicago Bridge & Iron Co.
Copperweld Steel Co.
Fisher Scientific Co.
Indiana Steel & Wire Co.
Minnesota Mining & Manufacturing Co.
York Corp.

*Individuals:*
Calef, J. F.
Chisdes, Meyer
Fitch, T. A.
Ganzler, Martin
Gray, Arthur W.
Howell, Francis M.
Pfarr, John S.

SUMMARY—*From 512 Contributors $147,048.43*

# A Message to Our New Members Particularly,— About the Character and Philosophy of the Society

EACH year we welcome to our midst new members. Last year there were 588 and it is to be expected that as many more will become members this year. Our membership is now about 5800 and since this includes not only individual but company memberships as well the people engaged in the work of A.S.T.M. must be two or three times this number. We are becoming a large organization and there is a chance that we may become too impersonal. This we hope will not happen and as our new members become acquainted with the spirit of A.S.T.M. they will come to realize that we must retain our character.

What is this philosophy and character of A.S.T.M. and what is there unique about it, and why should this be of interest to our new members? To appeal to so many people of diverse interests, our philosophy must fit broad human needs.

Everyone knows that all of the work of A.S.T.M. is voluntary and cooperative. There have been other cooperative endeavors and these have been successful too. The principal end result of our work is a standard or a method of test, an agreement as to the standard of quality. No one person receives credit for this result. The standards themselves are monuments of scientific and engineering endeavor. They represent important milestones of technological progress. They become the lasting tools of engineering. Yet there is no individual authorship and many contribute unstintingly to the work. This represents not only the splendid spirit of cooperation present in our work but truly bespeaks the character of A.S.T.M.

But what is the basis of this spirit, this cooperation, which seemingly does not feed on egoism. Of course, there is opportunity to render service, there are interesting problems to solve. All of us want to contribute to progress, there are friendly associations, there are interesting personal contacts and exchanges of viewpoint. These rather describe than explain the spirit of A.S.T.M.

I believe the motive of A.S.T.M. work represents one in the best flowerings of the thought that *anyone who is engaged upon an enterprise that offers problems to be solved, that continually opens new and challenging horizons as he proceeds, is a happy man.* To the new member, our committee meetings may at first seem dull, endless bickerings, whole and partial truths mixed, data incomplete, conflicting testimony, exceptions to all conclusions, a confused and a seemingly hopeless mess. Gradually order and clarity come out of the chaos, conflicting opinions merge, the data fit our understanding of the problem, and a new standard is born. No one but one who has struggled through these jungles can understand the joy and satisfaction that comes from the recognition of the final accomplishment. This work carries with it the feeling of the craftsman, the satisfaction an artist gets from his labor—the recognition at last of a fine new creation. The workman gets his hire as he proceeds and a big boost when the job is done. Since our effort is also intertwined with others, we have the added pleasure of sharing our satisfaction.

Our new members are accordingly urged to associate themselves with those committees of our Society where their interests lie. Our committees are designed not only to cover materials such as steel, aluminum, cement but also fabricated products, processes, methods of testing and cooperative research in materials. The usual procedure is to develop methods of test with which quality can be measured and then to establish limits of quality based on ability of the producer to manufacture and of the user to employ. In accomplishing these ends the whole range of scientific knowledge and technology may be and often is brought to bear on the problem.

J R Townsend

PRESIDENT

## 1946 Nominating Committee

IN ACCORDANCE with the By-laws, providing that the Executive Committee shall select a nominating committee for officers at its October quarterly meeting, the Executive Committee has considered the report of the tellers, Dr. Gilbert E. Seil, Technical Consultant, Day & Zimmerman, Inc., and Mr. J. J. Duffy, Jr., Assistant Manager of Sales, Pennsylvania Salt Manufacturing Co., on the recommendation of members for appointees on the nominating committee and selected the following committee and alternates:

| Members | Alternates |
|---|---|
| L. E. Ekholm, Alan Wood Steel Co. | T. G. Stitt, Pittsburgh Steel Co. |
| A. R. Ellis, Pittsburgh Testing Laboratory | E. O. Slater, Smith-Emery Co. |
| H. D. Baylor, Louisville Cement Corp. | A. G. Fleming, Canada Cement Co., Ltd. |
| L. C. Beard, Jr., Socony-Vacuum Oil Co., Inc. | T. G. Delbridge, The Atlantic Refining Co. |
| Stanton Walker, National Sand and Gravel Assn. | D. E. Parsons, National Bureau of Standards |
| D. L. Colwell, U. S. Navy Dept. | J. J. Kanter, Crane Co. |

(over)

The three immediate past-presidents, H. J. Ball, Dean Harvey and P. H. Bates, serve as *ex-officio* members of the 1946 Nominating Committee. The committee will meet in March and make nominations for each office—president, vice-president, and five Members of the Board of Directors. The revised By-laws provide that, following the 1946 Annual Meeting and with the approval of the Pennsylvania Court on revision of the Society's Charter, the former Executive Committee shall be constituted as a Board of Directors, and the Members of the Board are to serve for three years. The selections by the nominating committee will be announced to the members in the ASTM Bulletin prior to transmission of official ballots.

## Error in Distributing Part II 1945 Supplement to Book of Standards

A NUMBER of copies of Part II of the 1945 Supplement to the Book of Standards were distributed in which two errors had been made. One of these had to do with the placement of the green-tinted Table of Contents of the A.S.T.M. Tentatives. This should have appeared following page 108 but in these particular copies was inserted just following the regular Table of Contents.

These same copies were distributed without the yellow correction sheets which are to be used in indicating in the present 1944 Book of Standards those standards which have been superseded or revised. Anyone wishing to return one of these faulty copies may do so and a correct copy will be furnished. Copies of the yellow correction sheets are available on request.

### *A.S.T.M. Meetings*

| Date | Committee | Place |
|---|---|---|
| February 19, 20 | D-19 on Water for Industrial Uses | William Penn Hotel, Pittsburgh, Pa. |
| February 20–22 | B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys | Hotel Woodstock New York, N. Y. |
| February 25–March 1 | SPRING MEETING AND COMMITTEE WEEK | William Penn Hotel, Pittsburgh, Pa. |
| February 27, 28 | B-9 on Metal Powders and Metal Powder Products | Stevens Hotel, Chicago, Ill. |
| March 4, 5 | D-14 on Adhesives | Claridge Hotel Atlantic City, N. J. |
| March 6 | C-15 on Manufactured Masonry Units | Washington, D.C. |
| March 6, 7 | D-20 on Plastics | Claridge Hotel Atlantic City, N. J. |
| March 7, 8 | D-9 on Electrical Insulating Materials | Claridge Hotel Atlantic City, N. J. |
| March 11 | B-5 on Copper and Copper Alloys | Hotel Woodstock New York, N. Y. |
| March 13–15 | D-13 on Textile Materials | Park Central Hotel New York, N. Y. |
| March 17–20 | D-2 on Petroleum Products and Lubricants | Cleveland, Ohio |
| April 8, 9 | Executive Committee | Headquarters Philadelphia, Pa. |
| June 24–28 | Forty-Ninth Annual Meeting and Exhibit | Statler Hotel Buffalo, N. Y. |
| | DISTRICT MEETINGS | |
| February 14 | Philadelphia (Housing) | Franklin Inst. |
| March 19 | Philadelphia (Symposium on Low Temperature Effects) | Franklin Inst. |
| March 19 | Southern California | Los Angeles, Calif. |
| March 25 | Northern California Jointly with American Welding Society | San Francisco, Calif. |

## News on A.S.T.M. Publications

THE Staff and the several printers who work on A.S.T.M. publications are continuing to make progress on the number of volumes which are under way, including Part I on Metals and Part III on Nonmetallic Materials, General, of the 1945 Supplements to the Book of Standards. Part II on Constructional Materials has been mailed to those members who get it and the other Parts will go in the mails in the next few weeks, Part III about the middle of February and Part I in March.

The 1945 *Proceedings*, a volume of about 1200 pages, is being prepared and some forms have been released for press with the expectation that this book will be distributed to each member sometime in March. It includes a large number of technical papers which the Committee on Papers has selected for inclusion, including particularly those with permanent reference value, and all of the committee reports are given in the forepart of the volume.

In connection with the special compilations of standards of which the Society issues some twelve books, work seems to be of a continuing nature since new and revised books are continually being prepared. Those which are in course of preparation with publication expected in the next few weeks include the one sponsored by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys and the Compilation of Standards on Paint, Varnish, Lacquer, and Related Products, a book of some 500 pages with all of the specifications and tests developed by Committee D-1. The last compilation here was dated December, 1942, so there is a considerable demand for this revision. A new book, to be published for the first time will include all of the specifications and tests covering glass and glass products, about which there will be a further announcement.

Another article in this BULLETIN refers to the new Book on Methods of Chemical Analysis of Metals.

## Membership Committee Requests Aid

THERE is being distributed to each member of the Society a return form on which can be noted the names of individuals and com-

panies who might benefit from affiliation with the Society and who would be interested in A.S.T.M. work in the field of materials. The Committee on Membership, headed by W. C. Hanna, California Portland Cement Co., is desirous that every member who can should send the names of associates, or individuals they know, and these people will receive information about A.S.T.M. work and its publications. In the past suggestions from the members have been very valuable and have resulted in a number of new members.

The membership record for 1945 is an interesting one since more new members (588) qualified than for any other period. Nevertheless, due to more deaths and other losses the net growth did not exceed last year when fewer new members were received, but by a coincidence was exactly the same, 355. This means that the total membership as of December 31, 1945, was 5736, not including some 200 students. There was a rather heavy loss in Junior members and students, both attributable, of course, to the demands of the Armed services. There were 193 Sustaining Members, about 1500 Company and Association Members, and 4000 Individuals and others.

Entrance To New A. S. T. M. Headquarters

Just what the future has in store with respect to the membership curve cannot be accurately foretold, but there is no question that as the Society's work expands—and it is extending into many newer fields—there is a wider area of industry which is concerned with the standards and research programs. At the same time there are a large number of individuals and companies in fields where A.S.T.M. has been active for numerous years who would welcome the invitation to join with us. The continuing interest of A.S.T.M. members in connection with the growth of the Society through new members has been the chief factor in the steady rise of the membership curve to its present peak.

## Greatly Enlarged Volume on Chemical Analysis of Metals Being Prepared

**New Photometric and Polarographic Methods; Numerous Revisions and Amplifications**

THE 1946 edition of the Book of A.S.T.M. Methods of Chemical Analysis of Metals is now being prepared for publication and will be available this spring. The new edition will contain about 440 pages, or over 100 pages more than the 1943 edition. New material of special interest will include six tentatives covering photometric methods for the analysis of nonferrous metals and alloys. These methods have been prepared in a new and comprehensive style which should find especial favor with the analyst. They have been grouped in a separate section introduced by a recommended practice for photometry which presents a discussion of the many factors of special significance in photometric work. The new tentatives include:

- Recommended Practice for Photometric Methods for Chemical Analysis of Metals,
- Photometric Methods for Chemical Analysis of Magnesium-Base Alloys, which contain procedures for manganese, iron, copper, silicon, and lead,
- Photometric Methods for Chemical Analysis of Copper and Copper-Base Alloys, which contain procedures for nickel, phosphorus, iron, and manganese,
- Photometric Method for Determination of Iron in Copper-Nickel Alloys,
- Photometric Methods for Determination of Iron in Slab Zinc (Spelter),
- Photometric Methods for Determination of Iron in Lead- and Tin-Base Alloys, and
- Photometric Method for Determination of Bismuth in Pig Lead.

Polarographic procedures for lead and cadmium in slab zinc (spelter) and for zinc in lead- and tin-base alloys are being introduced. These represent the first ventures by Committee E-3 on Chemical Analysis of Metals into the field of polarography, and wherever they are applicable these procedures offer considerable promise of increased accuracy with appreciable saving of time.

Revisions in the Tentative Recommended Practices for Apparatus and Reagents for Chemical Analysis of Metals (E 50) include the addition of requirements for apparatus for the determination of sulfur by direct combustion, for nitrogen by distillation, and for polarographic analysis. A table of stoichiometrical equivalents of standard solutions used in the chemical analysis of metals is being included in E 50.

The Standard Methods of Chemi-

cal Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron (E 30) have been extensively revised and now include the procedure for selenium which was adopted as standard last year. New tentative methods are being published covering the determination of sulfur by direct combustion, and of nitrogen, in steel. When satisfactory standards have been set up, the accuracy of the combustion method for sulfur compares favorably with that obtainable by the older and much longer gravimetric procedures used hitherto. The time required is remarkably short, since a complete determination can be made in 20 minutes. The procedure for determination of nitrogen fills a gap which has existed for a number of years in analytical methods for steel.

The Methods of Chemical Analysis of Ferro-Alloys (E 31) have also been considerably revised, including a complete revision of the procedure for determining phosphorus.

As a result of the study of more detailed methods of sampling metals for chemical analysis, now being made in Committee E-3, the Methods of Sampling Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron have been removed from A.S.T.M. Standard E 30 and established as a separate standard. Tentative Methods of Sampling Slab Zinc (Spelter) are being published for the first time. The Methods for Sampling Wrought Non-Ferrous Metals for Chemical Analysis which appeared in draft form in the 1943 Book as information have now been approved as tentative.

The Methods of Chemical Analysis of Lead- and Tin-Base Solder and of White Metal Bearing Alloys have been revised and a procedure for zinc added to each.

The Methods of Chemical Analysis of Special Brasses and Bronzes have been revised and considerably augmented by addition of procedures covering the determination of iron, phosphorus, nickel, manganese, arsenic, and antimony.

The former Methods of Battery Assay of Copper (B 34) have been revised and reissued as the Methods of Chemical Analysis of Copper (Electrolytic Determination of Copper), which are now applicable to copper having a purity of 99.40 per cent and over.

The methods that appeared in the 1943 Book of A.S.T.M. Methods of Chemical Analysis of Metals have been reviewed and revised, and a number of the tentative methods have been advanced to standard. It is accordingly believed that users of the 1946 Book will find it of increased value due to the many new additions and the improvements in the procedures.

This compilation of the Methods of Chemical Analysis of Metals will be made available to members on request, with extra copies at the special price of $3, the price to nonmembers being $4.50. A request order blank will be distributed to the membership soon.

## Organizing Group Discusses Work of New Committee on Quality Control

In the announcement appearing in the December Bulletin on the new Technical Committee on Quality Control of Materials reference was made to an organizing group which would assist Temporary Chairman Harold F. Dodge in planning the committee's work, developing the personnel, and in general seeing that the committee started out with a clear conception of problems to be covered. This organizing committee has been appointed with the following personnel:

Harold F. Dodge (Chairman), Quality Results Engineer, Bell Telephone Laboratories, Inc., New York, N. Y.

A. G. Ashcroft, Director of Research, Alexander Smith and Sons Carpet Co., Yonkers, N. Y.

G. H. Harnden, Works Laboratory, General Electric Co., Schenectady, N. Y.

H. F. Hebley, Director of Research, Pittsburgh Coal Co., Pittsburgh, Pa.

F. T. Mavis, Professor of Civil Engineering and Head, Department of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

R. F. Passano, Metallurgical Engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.

A. E. R. Westman, Ontario Research Foundation, Toronto, Ontario, Canada

This group held a meeting in New York early in January and outlined a proposed statement of scope and discussed other problems. Basically, the new technical committee which will have a personnel representative of many industries and materials fields concerned, will promote knowledge of quality control methods and their influence and application in relation to specifications and test methods. Quality control methods generally are presumed to be those that are developed on a statistical basis and involve the control of quality through relation to specifications, production techniques and inspection. In addition to sponsoring technical contributions which may involve papers, reports, or recommended practices, it is expected that the new technical committee, designated E-11 on Quality Control, will be able to give helpful aid and advice to the many other Society technical committees which are concerned with specifications and test procedures. Still other problems in the province of the committee would be designation of numerical requirements in standards, sampling methods as related to conformative specifications and also with production control. The organizing committee plans to push the development of Committee E-11 and will meet again soon.

## Much Activity in Committee D-2 on Petroleum Products and Lubricants

The first postwar meeting of Committee D-2 and affiliated subcommittees was held in Cleveland on January 13 to 16, inclusive. A majority of the meetings were marked by an intensity of purpose to formulate programs of activities geared to the changed conditions. The change in tempo and increased diversity of Committee D-2 activities is readily appreciated by the transition from a normal two-day session to the need for a four-day session with sched-

uled meetings starting at 8 a.m. and lasting in several instances to nearly midnight.

It was decided to reorganize and expand one technical committee and create two new technical committees.

Technical Committee F on Diesel Fuel Oil will be expanded to a membership of approximately 100 and will have a comprehensive representation of petroleum refiners, engine manufacturers, and users including the industrial, agricultural, and railroad interests.

Before the war, aviation gasoline was an activity of Technical Committee A on gasoline. During the war, Committee D-2's contribution to the national aviation gasoline program was merged with other war agencies. As a result of the increased importance, a new Technical Committee on Aviation Fuel is being created. The committee's scope will include both aviation gas line and jet-propulsion fuels.

A new Technical Committee on Light Hydrocarbons will consider the problems which are peculiar to the increasing prominence of the highly volatile hydrocarbons as commercial products.

So that Committee D-2 will have the benefit of the commercial significance of its policies, the A.P.I. Marketing Committee is to be represented on Committee D-2 by L. C. Welch of Standard Oil Co., of Indiana and H. P. Hobart of the Gulf Oil Corp.

The question of creating adequate specifications for petroleum products, especially lubricating oil, has been under consideration by a Special Study Committee. This group advises that a majority of present lubricating oil test methods are identifying rather than indicating service requirements and are not adequate as a basis for purchase specifications. The study committee recommends that a new technical committee be created to correlate activity of the present "product" technical committees and be responsible for creation of adequate specifications.

The special A.S.T.M. report on Significance of Tests of Petroleum Products, first issued in 1928 as prepared by Committee D-2 in a pioneering effort to meet the growing demand for information on the significance of tests used in evaluating petroleum products, has been reprinted several times and is very widely used. Periodically, the publication has been reviewed by the subcommittees who had jurisdiction of the individual tests. It was decided to place this subject under a permanent subcommittee. Dr. F. D. Tuemmler, Shell Development Co., was selected as chairman.

A study committee was selected (O. L. Maag, Timken Roller Bearing Co., chairman) to determine if the problems relating to cutting oils were sufficiently unique and of sufficient interest to justify the creation of a technical committee.

It is planned to enlarge the activities of Subcommittee XV, Sampling and Gaging, by creating sections on gaging, sampling, temperature measurement, units of measurement, and tank calibration.

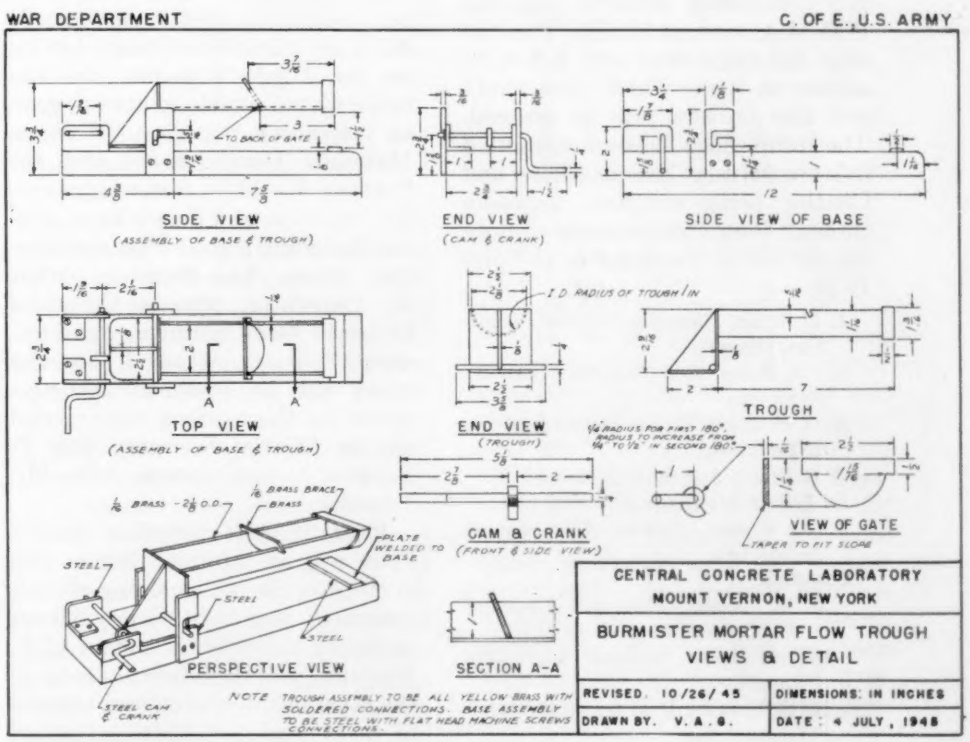
It was announced that the Spring Meeting of the committee would be held in Cleveland, March 17–20, inclusive. The Cleveland meetings were arranged by the D-2 secretary, D. V. Stroop, recently appointed Assistant to President, American Petroleum Institute, and T. A. Boyd, General Motors Research Laboratories, presided as the D-2 chairman.

## Burmister Flow Trough for Mortar

As THE result of co-operative study and comparative tests, there was recently presented to Committee C-1 on Cement, by its Sponsoring Committee on Portland Cement, a recommended revised design of the Burmister mortar flow trough that is required by the Tentative Method of Test for Air Content of Portland-Cement Mortar (C 185 – 44 T). This last design is much more complete than the design now shown in the tentative method, and differs in some details from the drawing which appeared in the 1944 December BULLETIN.

The following revision of Section 2 (*i*) of Method C 185 – 44 T contains certain important detail requirements that are now applicable but are not covered by the revised drawing.

"(*i*) The flow trough apparatus shall consist of a hemicylindrical trough of yellow brass closed at one end and operated by a cam to produce a drop of $1\frac{1}{2}$ in. from the horizontal position at the open end of the trough; and a solid steel base. The apparatus shall be constructed of the materials and to the dimensions shown in Fig. 1. The weight of the trough with the gate removed shall be 514 g. ± 5.0 g. and the balance point shall be located $1\frac{7}{16}$ in.



$\pm \frac{1}{16}$ in. from the closed end of the trough. The base shall be level, and the cam, heel plate, pivotal shaft, and pivotal shaft seat shall be clean and free from set cement, dirt, or grit."

Committee C-1 has approved this most recent design for submission to the Society as a recommended revision in Tentative Method C 185. Therefore, although the matter has not yet been the subject of action by the Society, the revised drawing of the trough is here reproduced and the proposed revision published as a matter of information in order to promote uniformity in equipment among those laboratories that plan the very early construction or purchase of new flow troughs.

## Joint Committee on Plastics Research Program

To ASSIST the Armed Forces in advising of technical problems and related matters that might well be covered in an extensive research program on plastics at Princeton University, which is being underwritten by the Army and Navy, A.S.T.M. Committees D-9 on Electrical Insulating Materials and D-20 on Plastics have appointed a Special Subcommittee to cooperate. This group is to function along lines similar to other groups which were concerned with the Surgeon General's prosthetics program and the P.M.M.A. work at M.I.T. Presumably the committee will primarily advise on items which need study and also on how best to proceed. The group which has been appointed follows, Messrs. Nason, Mains and Coutlee being *ex-officio* members through their chairmanship of Subcommittees in Committees D-9 and D-20:

J. D. Ryan, *Chairman*, Libbey-Owens-Ford Glass Co.
W. O. Baker, Bell Telephone Laboratories, Inc.
A. G. H. Dietz, Massachusetts Institute of Technology.
C. R. Stock, American Cyanamid Co.
D. Telfair, Monsanto Chemical Co.
A. J. Warner, Federal Telephone & Radio Corp.
*Ex-officio:*
H. K. Nason, Monsanto Chemical Co., Central Research Dept.
G. H. Mains, National Vulcanized Fibre Co.
K. G. Coutlee, Bell Telephone Laboratories, Inc.

## Philadelphia District Plans Meetings on Housing and Housing Materials, and Effect of Low Temperatures on Properties of Materials

Two meetings have been planned by the Philadelphia District. The first on February 14 will cover the subject of Housing and Housing Materials with Professor W. C. Voss, Head, Department of Building Materials and Construction, Massachusetts Institute of Technology, and John T. Grisdale, partner, Carroll and Grisdale, Architects, Philadelphia, as chief speakers. Both these men are very close to this field and interesting addresses are anticipated. A.S.T.M. President John R. Townsend will also provide material of interest by showing quite a number of slides from photographs which he took during his European sojourn, selecting those that will show both construction and destruction abroad. There will be other discussion of this vital subject.

A more extensive and somewhat more formal meeting is planned for March 19 when a committee headed by A. O. Schaefer, Midvale Co., will hold its Symposium on the Effect of Low Temperatures on Materials. There is a more detailed account on plans for this meeting elsewhere in this BULLETIN. Two sessions are contemplated, afternoon and evening, with an informal dinner. Abstracts or advance copies of the papers are expected, so that a number of authorities in this field may participate in the discussion. All members and committee members are cordially invited to attend.

## President Townsend and J. C. DeHaven at Cleveland District Meeting

AT THE meeting sponsored by the Cleveland District at the Cleveland Engineering Society on December 4, 1945, President John R. Townsend gave his address, "Research Revolutionizes Materials," and J. C. DeHaven, Battelle Memorial Institute, pinch-hitting for Dr. Clyde Williams who was taken ill and unable to attend, gave an interesting paper on "Wartime Materials Developments and the Postwar World." Something over 100 members and guests were present, including a good representation from Akron. Vice-President Arthur W. Carpenter, who is Cleveland District Vice-Chairman, presided, since Chairman Arthur J. Tuscany could not be present. Arrangements for the meeting were carried out by District Secretary Ray T. Bayless in conjunction with Mr. Tuscany.

Prior to the technical session there was an informal dinner with about 30 present, including district committee members, Society officers including Executive Secretary C. L. Warwick, and the officers of some of the other chapters and local sections of other societies whose members had been invited to attend the meeting.

At the dinner, the District Committee decided to take no action with respect to a formal statement on their views relating to the proposed building program advocated by certain groups in the Cleveland Technical Societies Council. Apparently a questionnaire is to be circulated among the Cleveland engineering group to establish a consensus on a number of points involved.

As the opening speaker, Executive Secretary Warwick in a short talk covered some of the high lights of the Society's activities, mentioning progress on the Headquarters Building, reorganization along administrative lines, and referred to some of the technical work which is being instituted.

Since Mr. Townsend's paper was published in the December BULLETIN, and Mr. DeHaven's is published elsewhere in this issue, no further comment seems necessary, except to say that they were received with much interest, and following the meeting there was considerable discussion. In response to one ques-

tion Mr. Townsend gave a summary of his reactions to the German communications system which he had studied intensively, indicating that in some few respects it was the equal of ours, but in many other ways the American developments far surpassed those of the Nazis.

## New York District Hears About Motor Fuels

In a most interesting discussion of the development of gasoline, and the notable advances made by American industry through its technologists in increasing both the quality and quantity of motor fuels, Dr. J. Bennett Hill, Manager, Development Division, Sun Oil Co., Marcus Hook, Pa., addressed the New York District on Tuesday, December 11, on the subject, "The War Pays Benefits to the Motorist." About 200 attended the meeting held in the Engineering Societies Auditorium. District Chairman Myron Park Davis, Otis Elevator Co., welcomed those present and introduced A.S.T.M. President J. R. Townsend, who presided as Technical Chairman. Executive Secretary C. L. Warwick was the first speaker, covering some of the recent developments in the Society and giving the audience an over-all picture of some of the administrative and technical advances.

Mr. Townsend, in introducing Dr. Hill, pointed out that at the Cleveland meeting where there was an interesting paper presented by James C. DeHaven of Battelle Memorial Institute on "Post-War Materials" (this paper is published in this Bulletin) the question had come up—are there any synthetic materials which are cheaper than the natural product? While no one present at the meeting could think of one at the moment, following it, President Townsend was advised of one—namely, processed gasoline which is cheaper than the natural product.

Dr. Hill traced briefly some of the earlier developments in gasoline. Through some excellent slides he acquainted the audience with many of the ramifications of the angle of quality. The data showed the great influence of the catalytic cracking process and its incalculable aid in providing fuel for our huge aircraft and World War II mobile equipment. During the war, the catalytic cracking capacity of the country was increased from 190,000 barrels per day in 1941 to 1,070,000 at the end of the war. One chart comparing the various constituents of the natural, thermal, and catalytic fuels showed that the anti-knock constituents of the catalytic were generally much higher.

In justifying his somewhat cynical attitude on the significance of the so-called octane number, Dr. Hill cited results from the last very extensive series of road tests run in California with leading automotive and petroleum experts participating. Comparing different fuels on the basis of low- and high-temperatures, at low and high speeds, it was evident that these factors definitely must be considered in connection with the octane rating. In other words, the octane number of fuels must be evaluated on the basis of several other conditions.

One could not help but leave the meeting with the feeling that gasoline is not simply gasoline, but that its use as a motor fuel is a complicated problem for the petroleum technologist. Nevertheless they have made and are making remarkable progress in furnishing the American motorist with what is required.

Dr. Hill was optimistic from the standpoint of quantity as well as quality. The meeting adjourned with the showing of two interesting films, *Report on the War Job* and the *Miracle of Gasoline Chemistry*, through the courtesy of the Sun Oil Co.

Before the technical session an informal dinner was held. General arrangements were under the direction of New York District Chairman Myron Park Davis, and assisting him were H. J. R. Carlson, Chairman of the Program Committee, and Messrs. G. O. Hiers, Secretary, and E. A. Snyder, Vice-Chairman, who cooperated in various matters, including the dinner.

## Officers to Visit West Coast

Acting on an invitation from the Southern and Northern California Districts, President John R. Townsend and Executive Secretary C. L. Warwick plan to visit these districts and participate in meetings which the respective districts will plan—one in Los Angeles on the night of March 19, and in San Francisco the week of March 25. On Monday, March 25, there is to be a joint meeting with the San Francisco section of the American Welding Society.

The officers of the Society desire to effectuate as close a relationship as possible with the growing number of members and committee members on the West Coast, and although the number of visits from Society officers has been limited in recent years it is hoped that each year there will be an opportunity to greet as many of the Pacific coast members as possible. The active group centering in the Los Angeles area is headed by E. O. Slater, Smith-Emery Co., with H. W. Jewell, Pacific Clay Products, Secretary, and in Northern California the district centers in San Francisco with Dozier Finley, The Paraffine Cos., Inc., Chairman, and P. V. Garin, Southern Pacific Co., Secretary.

## E. S. Lee Speaks in Northern California

Everett S. Lee, Engineer, General Engineering and Consulting Laboratory, General Electric Co., Schenectady, N. Y., will be the speaker at a meeting sponsored by the A.S.T.M. Northern California District in San Francisco at the Engineers Club on January 29. Mr. Lee will speak on "What is New in Science and Engineering" particularly from the standpoint of mechanical and electrical measurements and testing equipment. An account of this meeting will be in the March Bulletin. The meeting has been arranged by District Chairman Dozier Finley, and Paul V. Garin, District Secretary.

## Chicago Technical Societies Council Sponsors Production Conference and Exposition

The A.S.T.M. Chicago District is interested in the three-day Production Conference and Exposition which will be sponsored by the Chicago Technical Societies Council at the Stevens Hotel, March 20, 21, and 22. This is the first time this group has sponsored an exposition of this kind. Just what part the A.S.T.M. District may take in the conference is being decided by the local committee, which is headed by J. F. Calef, Automatic Electric Co., and further announcement will be sent directly to all members and committee members in the Chicago District. Meanwhile, those who may wish further information about this three-day meeting can write to the Chicago Technical Societies Council at 53 W. Jackson Boulevard, Chicago 4, Ill.

## Philadelphia Symposium on Low Temperature Effects

Under the auspices of the A.S.T.M. Philadelphia District there will be held at the Franklin Institute on the afternoon and evening of March 19, a Symposium on the Effects of Low Temperatures on Materials Used in Constructional Applications. Ferrous and non-ferrous metals, plastics, and rubber will be covered specifically. While war problems, including the use of materials at extremely low temperatures intensified the development of data on how various materials and assemblages reacted at low temperatures, even before the war, there was much interest in this subject because of problems in connection with refrigeration, chemical processes, etc. The Philadelphia District, of which L. E. Ekholm, Alan Wood Steel Co., is Chairman, feels that the subject is a very timely one and that it is particularly fortunate in obtaining the acceptance of the authors indicated below.

A. O. Schaefer, Executive Metallurgical Engineer, Midvale Co., has been serving as Chairman of the Symposium Committee, and F. B. Foley, Director of Research, Midvale Co., and G. E. Landt, President, Philadelphia Textile Finishers, Inc., have been developing the parts of the program involving metals and nonmetals, respectively. The program follows:

*General Aspects of Effects of Subatmospheric Temperatures on the Properties of Metals*—Maxwell Gensamer, Professor of Metallurgy and Head, Department of Mineral Technology, Penn State College, State College, Pa.

*Effects of Subatmospheric Temperatures on the Properties of Non-Ferrous Metals*—Normal L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric Corp., Philadelphia, Pa.

*Effects of Subatmospheric Temperatures on Weldments*—Robert D. Stout, Welding Research, Department of Metallurgy, Lehigh University, Bethlehem, Pa.

*Low Temperature Behavior of Organic Plastics*—Howard K. Nason, Director of Development, Central Research Labs., Monsanto Chemical Co., Dayton, Ohio

*Behavior of Elastomers at Low Temperatures*—J. W. Liska, The Firestone Tire and Rubber Co.

Tentatively, it is planned that the afternoon session would include the papers on nonmetallic materials, beginning probably at 3:30 p.m., followed by an informal dinner, with the evening session on metals getting under way at 8 p.m. sharp. Mr. Landt will preside as Technical Chairman of the afternoon session, and Mr. Foley for the evening meeting.

All members of the Society and committee members and those interested are cordially invited by the District to attend this session. It is hoped short abstracts of the papers will be available in advance. There will be discussion by a number of others in this field, perhaps covering effect of temperatures on materials other than those covered in the papers.

In arranging any technical program at this time, no one can foresee what repercussions may be forthcoming from the present wave of strikes, which prevent many men from getting to their offices. It is suggested to those who may be coming from some distance to attend the meeting, that they advise A.S.T.M. Headquarters, and last minute changes will be communicated to these men.

## New England District to be Organized

As a result of discussions with active members in New England, particularly in the Boston area, and a study of returns from a short questionnaire sent to all members and committee members in New England, the Executive Committee has authorized the formation of a District Committee which may be called the New England District, or the Northeastern District, depending on reactions from the members in the New England area. The Society has several hundred members in the New England states, particularly in Massachusetts, Rhode Island, and Connecticut, and there have been members of the Executive Committee and several officers of standing committees who are located in New England industrial centers.

Just when the organization meeting of the group will be held remains to be decided, but it is hoped that late this spring the District Committee can be appointed and organized. This will be the eleventh A.S.T.M. district.

### Polarographic and Spectrographic Analysis of High Purity Zinc and Zinc Alloys for Die Casting

A Booklet of 117 pages bearing the above title covers the work of a British Standards Institution Panel on the problem of analyzing high purity zinc and zinc alloys for die casting. The publication consists of four papers by competent investigators and relates to work done from 1941 to 1944. The paper covering the polarographic analysis of the metals studied is exceptionally well done and presents procedures well worth consideration and study for possible use in this country.

The spectrographic papers are well written and clearly show that spectrography was not dormant in England during the war years. Each of these papers presents a wealth of data that should prove to be of great value to all workers in the field of the spectrographic analysis of metals.

The publication is recommended to all students of polarography and spectrography, regardless of whether or not they are interested in zinc and its alloys. It is available from His Majesty's Stationery Office, 429 Oxford Street, London, W. 1, at a quoted price of 5s.

H. V. Churchill

## Symposium on Ultra High Voltage and High-Speed Radiography at National Metal Congress

NINE technical papers and discussion are to be presented in a joint Symposium on Ultra High Voltage and High-Speed Radiography which has been developed under the auspices of A.S.T.M. Committee E-7 on Radiographic Testing, to be given at the National Metals Congress in February in connection with the meetings of the American Industrial Radium and X-ray Society. One full day is being devoted to the symposium with the program for the other two days being arranged by the A.I.R.X.S. Dr. H. H. Lester, Watertown Arsenal, chairman of Committee E-7, has taken the lead in connection with the symposium, with other E-7 members cooperating closely.

The program for the symposium follows:

1. The "Betatron": Prof. D. W. Kerst, University of Illinois
2. Discussion of Rock Island Arsenal "Betatron": D. W. Marchant, Rock Island Arsenal
3. Discussion of Naval Research Laboratory "Betatron": H. F. Kaiser, Naval Research Laboratory
4. European Induction Accelerators: H. F. Kaiser, Naval Research Laboratory
5. Electron Accelerator and the Two Million Volt Resonance Transformer Radiographic Equipment: E. E. Charlton, General Electric Co.
6. Radiography with the Two Million Volt Electrostatic Generator X-ray Machine: Prof. R. J. Van de Graaff and Associates, Massachusetts Institute of Technology
7. Naval Experience with the Two Million Volt Electrostatic Generator Radiographic Equipment: Lt. D. T. O'Connor, USN, Ordnance Investigation Laboratory, Naval Powder Factory
8. High-Speed Radiography: Dr. C. M. Slack, Westinghouse Electric Corp.
9. Frankford Arsenal Experience with High-Speed Radiography: Edward R. Thilo, Frankford Arsenal

### Tables for Measurement of Oil

PRODUCED by the Measurement and Sampling Subcommittee of the Institute of Petroleum, London, this book meets the demands of the petroleum industry for authoritative tables for use in computing oil quantities where the British (Imperial) system of weights and measures apply. Countries using the United States system of weights and measures have the official National Bureau of Standards Circular C 410 as a standard. The work can, therefore, be regarded as the official British counterpart of the American publication but it is more extended in scope. The main tables contained in Circular C 410 have been recalculated to allow entry to be made with specific gravity instead of A.P.I. gravity, and they have been supplemented with additional tables. These additional tables, giving weights per unit volume and volumes per unit weight, have been computed using, wherever possible, basic data which is legally recognized, or which recent meteorological research has shown to be most accurate. For these reasons the tables will also find wide application in the American oil industry. Copies of this 320-page publication can be obtained from the British Institute, Manson House, 26, Portland Place, London, W. 1. at 25s. or $6.00.

## Abstracts of 1946 Preprints of Papers for Advance Distribution

(SEE REQUEST BLANK ON PAGE 66)

**Compressive Properties of Aluminum Alloy Sheet at Elevated Temperatures.** Alan E. Flanigan, Leslie F. Tedsen, and John E. Dorn.

Describes an apparatus that has been developed to allow the compression testing of sheet materials at elevated temperatures. It includes a testing fixture, a special extensometer, and an oil-bath furnace which are described in detail. The short-time compressive properties of five high-strength aluminum alloy sheet materials have been determined at temperatures up to 300 F. after exposures ranging from 1/2 to 1000 hr. The materials include 24S-T, 24S-T81, 24S-T86, R301-T, and 75S-T. The effects of temperature and time on compressive yield stress are compared with those for the corresponding tensile properties and it is found that approximate values of compressive yield stress may be derived from calculations based upon the tension values.

**A Study of the Geometry of the Tension-Impact Specimen.** N. A. Kahn and E. A. Imbembo.

Data are presented on the effect of the geometry of the tension-impact specimen on the energy values obtained from the tension-impact test. This paper indicates the effect of the $L/D$ ratio of the test section and includes recommended values of same in order to obtain a true measure of the tensile-impact resistance of metallic materials, as determined by tests conducted in the conventional Charpy pendulum-type impact testing machine. Tension-impact data for medium steel, austenitic type corrosion-resisting steel, copper, Naval rolled brass, nickel-copper alloy (Monel), and 17S-T type aluminum alloy at various $L/D$ ratios are included.

**Calculation of Electrical Contacts Under Ideal Conditions.** Erle I. Shobert II.

In most practical applications of electrical contacts, the choice of materials and contact forces is largely a matter of trial and error and of the experience of the designer. In this article a series of calculations is presented in which some of the variables in contacts are put in their proper relationship. As a result, the designer in certain fields of application may estimate such factors as maximum temperature rise, and knowing the mechanical and electrical characteristics of the various contact materials, he can predict the results. The calculated results are based upon contacts under ideal conditions: that is, no surface films and undisturbed smooth surfaces. The experimental data and the comparison of the predicted results with present industrial practice show that the method may be used to calculate the fundamental relations of contact resistance, contact force, and temperature rise, and that these data may be applied to practice with the proper allowance for the factors not considered in the calculations.

**The Influence of Gypsum on the Hydration and Properties of Portland Cement Pastes.** William Lerch.

Twelve commercial clinkers, representing the range of chemical composition found in portland cements, were ground in a laboratory mill with various additions of gypsum. The resulting cements were used to study the influence of gypsum on the hydration and properties of portland cement pastes. Five of the clinkers were ground in commercial mills with approximately 1.8 per cent $SO_3$ to three widely different specific surfaces. The latter cements were used to study the influence of fineness upon the rate of hydration with $SO_3$ constant.

A conduction calorimeter was used to determine the rate of hydration of neat cement pastes, the rate of hydration being expressed in terms of the rate of heat liberation. Mortar prisms were used to determine the physical properties of the hardened paste—strength, expansion in water, and contraction in air.

**A Method of Particle Size Determination of Soils, Cement, etc., by Means of a Chainomatic Specific Gravity.** E. V. Barrett.

A method of particle size determination of soils, cements, and other fine-grained materials has been developed in the Materials Testing Laboratory of the Ministry of Public Works in Caracas, Venezuela. This method employs a chainomatic specific gravity balance with a 2 cc. spherical glass plummet suspended by a stainless steel wire 0.0008 in. in diameter. The method permits the accurate determination of the specific gravity of a suspension of fine particles in a liquid medium at any predetermined depth. The use of this method eliminates the computations and corrections of the hydrometer method and permits the determination of the per cent of soil particles finer than 0.0015 mm. to be made in 72 min. instead of the 24 hr. required by the hydrometer method. The determination of the specific surface of a sample of portland cement can be made in about 7 1/2 min., particle size being determined to 0.005 mm.

# Reviews of Books on Statistical Analysis, Quality Control, etc.

BELIEVING that many of our members and committee people would be interested in an evaluation of the leading books covering the field of statistical analysis, quality control, etc., there appear below synopses of reviews of these books as published in the September *Journal* of the American Statistical Association. It is unfortunate that we cannot publish the reviews completely because they are splendidly done, each of the reviewers himself being an outstanding authority in this field, but it is hoped sufficient of the material is used to convey to our members some idea of the scope and value of the various publications. It should be emphasized that although the reviewers' names are given, in some cases a few liberties have been taken with the abstracts so that the phrasing is not exactly as prepared by the reviewers.

These reviews are pertinent, not only because of the growing interest in the whole field of quality control, inspection, etc., but because of the formation by the Society of a new technical Committee E-11 on Quality Control, as announced in the December BULLETIN. (See also page 54, this issue.) H. F. Dodge, who for a number of years has been chairman of the Society's Subcommittee on Interpretation and Presentation of Data, has accepted the temporary chairmanship of the new committee.

The material which follows is reprinted with the kind permission of the American Statistical Association. The *Journal* Review Editor is Oscar Krisen Buros. Lester S. Kellogg is Secretary-Treasurer of the ASA. Copies of the complete reviews can be obtained at a nominal price from the association offices 1603 K St., N. W., Washington 6, D. C.

**A.S.T.M. Manual on Presentation of Data: Including Supplement A, Presenting ± Limits of Uncertainty of an Observed Average; Supplement B, "Control Chart" Method of Analysis and Presentation of Data; and Tables of Squares and Square Roots. Sponsored by Committee E-1 on Methods of Testing.** Philadelphia: American Society for Testing Materials, 1945. Pp. ix, 73. $0.85. Paper.

The Manual (main body, 1933; supplements, 1935) has been kept up to date by minor changes in each printing since 1935. The A.S.T.M. committee responsible is composed of engineers who are also statistical experts. It is particularly because engineers meeting this description are so rare that this excellent manual has proved so helpful to the engineering profession. In this connection Dr. C. G. Darwin, Director, British National Physical Laboratory... has said we need "to inculcate in people's minds the idea that every number has a fringe, that it is not to be regarded as exact but as so much plus or minus a bit, and that the size of this bit is one of its really important qualities."

It is partly because many engineers have never been sufficiently aware of the inevitableness of variability that they have not informed themselves about the best methods of dealing with variability. This lack of statistical sophistication can lead to many bad consequences, such as uncritical specification of manufacturing tolerances, the specification of uneconomical and ineffective acceptance procedures, wasted data in research and development work, and inefficient presentation and analysis of experimental results.

The main body of this manual gives direct help to engineers in presenting experimental results. . . .

Supplement A discourages engineers from their traditional use of probable error as a measure of the reliability of an observed average. In its place are substituted certain limits. . .

Supplement B, of special current interest because of the great wartime expansion of the use of statistical quality control techniques in industry, gives a concise description of the Shewhart control chart and might well be required reading for all practicing statisticians and teachers of statistics. . . .

[Review by EUGENE L. GRANT, Professor of Economics of Engineering, Stanford University.]

**Guide for Quality Control and Control Chart Method of Analyzing Data.** American War Standards, Z1.1—1941 and Z1.2—1941. New York: American Standards Association, 1941. Pp. 15, 47–66. $0.75. Paper.

**Control Chart Method of Controlling Quality During Production.** American War Standards, Z1.3—1942. New York: American Standards Association, 1942. Pp. 41. $0.75. Paper.

The three Standards form an excellent text on the control chart procedures developed by Shewhart. . . .

Z1.1 is a five-page exposition of the general quality control problem in which the concept of a state of statistical control is established and the control chart is described and illustrated for averages of measurements taken from small samples. In Z1.2, the computational steps are shown for the construction of control charts for measurements. . . .

The second booklet, Z1.3, is a well-organized text on control chart procedure. This pamphlet considers all the standard kinds of control charts. . . .

The quality control procedure is discussed starting with the questions of what data to gather, how to collect and group them, and how to treat the data once gathered to get the appropriate control chart. . .

As to the two booklets, Z1.3 is, in general, better organized for use in practice. . .

[Review by FREDERICK MOSTELLER, Research Mathematician, Statistical Research Group, Princeton University.]

**Statistical Adjustment of Data.** W. Edwards Deming (Adviser in Sampling, Bureau of the Budget, Washington, D. C.), New York: John Wiley and Sons, Inc., 1943. Pp. x, 261. $3.50 (London: Chapman and Hall, Ltd., 1944. 21s.).

In this book a great many types of problems are considered under the general principle of least squares. . .

It has a number of distinctive features. The example in which random errors of known variances are added to both coordinates of selected points on a parabola (pp. 218–30) is praiseworthy because it permits the reader to compare each aspect of any given practical problem with the corresponding aspect of the example in order to assure himself that the two problems are comparable. . . . The section on conditions without parameters contains important types of problems which are rarely presented in statistics books, and the material on estimation of cell frequencies is indeed timely as the author suggests in the preface. The technical discussions are liberally supplemented with bits of good practical advice. The author has done a scholarly piece of work assembling materials bearing on the general problem of adjustment of data and adapting them for his purposes. Since original articles in this field are not readily accessible, the many well-chosen references and historical notes are especially helpful.

The author's contributions to the specialized and relatively difficult problems which he emphasizes hardly justify his overoptimism with respect to the relative effectiveness of the proposed methods. Since a considerable amount of effort is still required to solve some of the problems, it is unfortunate that the author tends to conceal relative advantages by emphasizing conditions under which a given approximate method yields results which are good enough for purposes of action rather than those under which the method has comparative advantages. . . .

The author's treatment of errors in cell frequencies is not convincing with respect to the theoretical advantages of the proposed methods even under ideal conditions. . .

[Review by JOHN H. SMITH, Acting Chief Statistician, Bureau of Labor Statistics, Washington, D. C.]

**Sampling Inspection Tables: Single and Double Sampling.** Harold F. Dodge and Harry G. Romig (Bell Telephone Laboratories, Inc., New York, N. Y.). New York: John Wiley & Sons, Inc., 1944. Pp. vi, 106. $1.50. (London: Chapman & Hall, Ltd., 1945. 9s.)

The tables are for use in nondestructive acceptance inspection of lots. The sampling plans embodied in the tables assume that items from a production line are submitted to a consumer in lots, that each item is either conforming or defective, and that the consumer accepts some lots after inspection of a sample, others after complete inspection. The sampling plans seem originally to be intended for and are best suited for the case in which the consumer and the producer are parts of the same organization or where the inspection is carried out by the producer in the interests of the consumer. . . .

The text of the book explains the motivation of the plans and derives the formulas which may be used to set up sampling inspection plans subject to either class of objectives and to either limitation on type of plans considered. . . .

Since the legitimate uses of data collected under a sampling plan depend on the method of and not the reasons for collection, the extensive data given in the tables can be used for purposes other than those implied by the stated primary objectives of the plan. Thus, in the book under review, while the

plans proposed are initially restricted in purpose to acceptance inspection (*i.e.*, to control of quality of accepted lots), the authors rightly describe their use in quality control (*i.e.*, in the control of quality of production).

Several other sampling inspection plans are now available which admit a broader class of sampling procedures while preserving a significant part of the objectives of the Dodge-Romig plans. The inadequacy of presently available comparisons of these various plans leads one to hope that someone soon will take it upon himself to systematically list objectives and restrictions on types of sampling...

[Review by KENNETH J. ARNOLD, Senior Mathematical Statistician, Statistical Research Group, Columbia University.]

**What the Figures Mean.** Stephan Gilman (Vice-President and Educational Director, International Accountants Society, Inc.). New York: Ronald Press Co., 1944. Pp. ix, 127. $2.50.

... under war conditions and governmental controls the compiling, summarizing, and interpreting of figures has become a major business activity. This is true not only of the large corporation but of the little business the proprietor of which burns midnight oil over figures... Not only has figure work become a major activity of business, but its balloon-like expansion has found too many individuals unprepared to understand the results.

It is an informal sort of book, deliberately kept simple so that it may better meet the needs of those for whom more orthodox but more elaborate statistical treatment has little interest.

The above quotations explain the purpose and nature of the book. There is some doubt about the person who should be selected as the one best qualified to do the work which will answer the question, "What do these figures mean?"... The author eliminates the accountant, the statistician, and the statistical mathematician... This situation would seem to force the business man to analyze his own data after reading this book but he is not apt to be very enthusiastic about this prospect. The reviewer would recommend that the business man employ a business statistician, who is different from the man the author seems to have in mind when he describes a statistician... Today we are training business statisticians who can give very practical help. If the business man cannot or will not employ a good business statistician, then the methods given in this book would be the next best choice. This book is the best one of its kind the reviewer has encountered....

In those universities and colleges which still cling to the practice of giving a course in business management or industrial management to students who have not previously completed a course in business statistics, this book would serve very well as one of the textbooks for the course in business management.

[Review by HARRY PELLE HARTKEMEIER, Professor of Business Statistics, University of Missouri.]

**Management of Inspection and Quality Control.** J. M. Juran (Formerly Chief of Inspection Control Division, Western Electric Co., Inc.). New York: Harper & Bros., 1945. Pp. xv, 233. $3.00.

This book is a significant and well-written contribution to the current literature of industrial quality control. As often stressed, manufacturing faces ever greater precision requirements in complex products and processes. Further, screening inspection, scrap, and rework have become major factors in manufacturing cost. The parallel development of the science of control in technical and operating phases of manufacturing is of paramount importance.

The author presents sound principles and a well-rounded evaluation of problems of quality specification, inspection philosophy, lot acceptance sampling, control sampling, inspection organization and lines of responsibility, and last but foremost of the over-all management problem. Process control is presented at a level of practical investigation and direct adjustment, when statistical checks on generally developed processes and products depart from quality standards... The author stresses the importance of training in statistics for key technical personnel, responsible for over-all guidance and special investigation.

Although the author conforms admirably to the stated scope of his book, it would have been of great value to have him elaborate upon the engineering phases of process operation and quality control... For engineering visualization of the dynamics of propagated variability it is necessary to require higher orders of training in statistical theory and methods. Many operating improvements can be resolved only in this manner.

Likewise, in engineering design and specification such approach is necessary to evaluate inter-related tolerance ranges, proper reference coordinates, economically balanced specification limits, etc. Similarly the projection of inspection methods and sampling requires technical and statistical reasoning beyond mathematical computation.

The developments of practical quality control during the last few years have been significant and much of it has not been published... This book provides much needed examination of the over-all problem of management. There is still required presentations of the engineering methods of process control.

In general, we have a great problem in education and training throughout industry for technical, managerial and supervisory personnel. Mr. Juran's book should be in every industrial library, and should be collateral reading in engineering schools.

[Review by A. I. PETERSON, Quality Control Manager, Radio Corporation of America, Harrison, New Jersey.]

**Elementary Statistics.** Hyman Levy (Professor of Mathematics, Imperial College of Science, London) and E. E. Preidel (Assistant Lecturer in Mathematics). New York: Ronald Press Co., 1945. Pp. vii, 184. $2.25. (London: Thomas Nelson & Sons, Ltd., 1944. 5*s*.)

This book, although it was written as an elementary textbook in statistics, could also be regarded as an attempt to explain to the layman the basic ideas of statistics. The authors quite intentionally dispense with mathematical rigor and thus gain in simplicity. The book has the advantage of discussing only a few but very important statistics, namely: mean value, variance, correlation coefficient, and range....

The book can be recommended as a textbook for a short first course in statistics. It can also be recommended to any reader who wishes to acquaint himself with the intuitive basis of statistics without studying its mathematical foundation.

[Review by HENRY B. MANN, Brown University.]

**An Introduction to Statistical Analysis, Revised Edition.** C. H. Richardson (Professor of Mathematics, Bucknell University). New York: Harcourt, Brace & Co., 1944. Pp. xiv, 498. $4.00.

The earlier editions of the book, which appeared in 1934 and 1935, enjoyed considerable popularity. The book was perhaps the best text of its kind then available. But the picture in statistics has greatly changed since 1935...

It seems only fair to use a sort of double standard in evaluating the book, and to consider it separately as a textbook in elementary mathematics and as a textbook in statistical analysis.

As a textbook in elementary mathematics, to be used for purposes of drill in formal operations, and as a technical basis for further mathematical work (but not necessarily in mathematical statistics), this book is well written and well organized... The book is obviously the work of a skillful and competent teacher of college mathematics.

But from the statistical point of view, the trouble with the book is that it is just about fifteen years out of date. . . . It is in the study of the relation between probability and statistics that the greatest advances have been made, and when the book skirts on such problems, the effect is quite disconcerting. The one chapter on probability appears late in the book. The chapter is a modest one and the treatment is mainly intuitive...

The job of writing a good textbook in mathematical statistics at the elementary level, which will achieve the stated aims of this one, is not an impossible one; but the author of such a text must realize that the derivations which fall within the scope of his work are not really of great value from the point of view of giving the student insight into the theory of statistics, and are useful mainly as drill in elementary formal mathematics. To be broadly useful, the work must therefore combine some mathematical elegance with plenty of good, accurate verbal exposition of the type which is beginning to appear now in our best applied statistics texts. This will be a hard job. It will be done by someone who is thoroughly at home in the work of R. A. Fisher, J. Neyman, E. S. Pearson, S. S. Wilks, W. A. Shewhart, H. Hotelling, and the other leaders of modern mathematical statistics, and who has had practical experience in two widely separated fields: applied statistics and instruction in mathematics at the college level...

[Review by J. H. CURTISS, Lieutenant, USNR, Bureau of Ships, Washington, D. C.]

**A First Guide to Quality Control for Engineers.** E. H. Sealy (Ministry of Supply Advisory Service on Statistical Method and Quality Control, London). London: Ministry of Supply, 1943. Pp. 38. Gratis. Paper.

This booklet, produced mainly by Dr. E. H. Sealy while he was with the British Ministry of Supply, was written, "primarily for use by engineers ... as a downright working guide for the man who, having decided that quality control is worth trying, wants to experiment with it on his own shop floor. It is not the object of this book to sell quality control to anybody, or to demonstrate the advantages. . . . Neither . . . to detail any of the mathematical theory which lies behind the subject. . . ." The book accomplishes these aims with distinction and with the unmistakable masterful touch of an author who understands the underlying mathematical theory and has contributed to it, but who does not flaunt it; one who also knows his way around in engineering and shop-practice, and appreciates what is needed in the way of clarity.

The book explains the author's "modified control limits", which successfully meet most of the difficulties encountered in the use of control charts in shops where tool-wear gives rise to a continual drift in the dimensions

being cut. The modified control limits are action lines drawn on the chart for averages; their function is to show whether the product is meeting the specifications and to forewarn the operator of the impending need for regrinding or resetting before rejections occur. The position of the modified control limits is determined by measuring inward from the drawing tolerances. . .

The booklet is filled with numerous illustrative examples, concisely and clearly discussed. . . The book contains the requisite tables for placing control limits. It is without doubt a distinct contribution to statistics in industry. . .

[Review by W. Edwards Deming, Adviser in Sampling, Bureau of the Budget, Washington, D. C.]

**Statistical Methods in Industry.** L. H. C. Tippett (Statistician to the British Cotton Industry Research Association). London; Iron and Steel Industrial Research Council, British Iron and Steel Federation, 1943. Pp. 74. *2s. 6d.* Paper.

This pamphlet includes an introductory lecture on "Probability Theory and Statistical Method" by Professor E. S. Pearson and a series of six subsequently given by Mr. Tippett at the University of Sheffield, Sheffield, England, at the request of the Open Hearth Committee of the Iron and Steel Industrial Research Council, together with a summary of the general discussion that followed the last lecture of the series. The presentation is clear and nontechnical in character and examples are chosen mainly from the steel industry. . .

This pamphlet includes the discussion that followed the lectures. This brought out information of a technical nature to justify certain statistical conclusions and in some places raised doubts concerning the statistical processes proposed. Many papers published in this country would make more interesting reading if similar discussions were included. . .

These lectures, prepared so carefully by an authority in applied statistics, should prove interesting particularly to the development engineer because they show how he may be helped by working with a competent statistician. By inference, they also make it clear that either the engineer or the statistician working alone is apt to draw erroneous conclusions that may be avoided by working together and thereby making use of the technical skills of both. . . Some may feel that these lectures are not an adequate introduction to the role of statistical method in so far as it applies to sampling consumer wants, research and development, design, specification including the setting of tolerance limits, inspection, and operational research to determine that standards are satisfactory, adequate, dependable, and economic. Obviously, all of these come under the general problem of quality control in industry.

[Review by P. S. Olmstead, Bell Telephone Laboratories, Inc., Murray Hill Laboratory, Murray Hill, New Jersey.]

**Quality Through Statistics.** A. S. Wharton (Technical Adviser Statistics, Philips Lamps Ltd.). London: Philips Lamps Ltd., 1945. Pp. iv, 60. *6s.* Paper. (Arlington, Va.: Gryphon Press, 1945. $1.50.)

This book sets forth in readable fashion statistical methods that have been found most useful in improving manufacturing quality in the factories of Philips Lamps Ltd.

Writing for those engaged in production work, the author emphasizes the point that only the simplest quality control schemes, devoid of "the jargon and symbols of higher mathematics" and readily comprehended in the factory, will prove satisfactory in practice. He describes a number of simple procedures that have proved their worth as well as others that appear to have promise. Keeping the presentation at an application level . . . may have been responsible in part for some inadequacies of technical explanation.

The problem of controlling quality is broken down under three general subjects: (a) Batch-by-batch receiving inspection of raw and processed materials used by a manufacturing unit, (b) Control inspection in process, and (c) Analysis of cumulative results of inspections to establish standards of performance and efficiency.

On the subject of batch-by-batch inspection, a special table of sampling plans has been devised to provide what is spoken of as a "control" at any one of several values of per cent defective, ranging from ½ per cent to 10 per cent. The inclusion of a few numbers or curves showing probability of acceptance vs. per cent defective in submitted batches, would certainly have clarified the significance of the sampling tables. The program for detailed analysis of the percentage of rejects, subdivided into types of faults, can be warmly endorsed . . .

On the subject of controlling quality during production, several simple control chart systems are presented with well-designed forms that should require a minimum of paper work. All follow the usual pattern, covered by publications in this country and abroad. . .

The third subject treated is one that needs to be emphasized time and again, namely, that we should make more use of collective inspection data (a) for improving our knowledge of the performance of individual machines, of individual operators, and of whole departments, and (b) for establishing overall standards of performance. . .

The book has sorted out and presented under one cover a set of specific control techniques that have been found highly useful. All in quality control work will be interested in the simplified charts and forms presented. Where greater refinements are wanted, reference may be made to the more technical literature cited.

[Review by H. F. Dodge, Bell Telephone Laboratories, Inc., New York, N. Y.]

**A Guide to Utilization of the Binomial and Poisson Distributions in Industrial Quality Control.** Holbrook Working (Economist, Food Research Institute, Stanford University). Stanford, Calif.: Stanford University Press, 1943. Pp. 15. $0.25. Paper. (London: Oxford University Press. *2s.*)

This pamphlet contains a wealth of valuable information. It consists of four parts covering: (a) binomial distribution, (b) devices for facilitating use of the binomial distribution, (c) the Poisson distribution, an aid to its utilization, and (d) approximations in the application of statistical theory. . .

Two very interesting diagrams, that to the best of my knowledge, have not appeared elsewhere should be found to be one of the most valuable parts of this paper, giving a clear-cut picture of the nature of the binomial and Poisson distributions. . .

Two charts for the Poisson distribution are presented covering: (a) probability limits, and (b) cumulative probability values. . .

Considering the paper as a whole, it may be considered an excellent presentation.

[Review by H. G. Romig, Bell Telephone Laboratories, Inc., New York, N. Y.]

## Magnesium and Its Alloys

A very interesting handbook on magnesium has just been written by John Alico. It is called "Introduction to Magnesium and Its Alloys" and is published by Ziff-Davis Publishing Co., Chicago, Ill.

The book has a Foreword by A. W. Winston of Dow Chemical Co., who compliments Mr. Alico on filling a need which has long existed in this country for a critical survey of available information on magnesium and its alloys. This is certain to be of interest to serious metallurgical students as well as those concerned with the practical aspects of fabrication and use of the metals.

The book starts with a brief summary of the historical and economic development of the magnesium industry and with information on the occurrence of magnesium and the production of magnesium metal. Subsequent chapters deal with the metallurgy of magnesium and its alloys, the casting of magnesium alloys, the forging, rolling and extruding of magnesium alloys, their heat treatment and surface treatment, their machining, and joining, together with an estimate of the role that magnesium will play in postwar product design.

The book is illustrated and contains much tabular data. At the end of each chapter there is an extensive bibliography giving the sources of information which Mr. Alico has compiled into a very readable book; while an index of the various subjects covered is also appended.

The book is 6 by 9½ in. in size, with approximately 200 pages, and is priced at $5. It can be obtained from the publishers, 250 Fifth Avenue, New York City 1, or 185 N. Wabash Ave., Chicago 1.

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## Use of A.S.T.M. Specifications

The standard specifications and methods of testing issued by the Society are used in a great variety of ways, and find their way into numerous pamphlets and books and other publications. We were interested in noting the reprinting by the U. S. Departments of Agriculture and Commerce of the A.S.T.M. Specifications for Hollow Load-Bearing Concrete Masonry Units (C 90 – 44) in the publication, "Will Making Concrete Block Pay in Your Community?" being one of the Industrial (Small Business) Series No. 23. The objective of these bulletins is to be helpful to individuals and communities in planning for increased peacetime local employment. Copies can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 15 cents each.

## Resume of Work of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys

EDITOR'S NOTE: The following material was contributed by Dr. Rawdon, chairman of this committee in connection with the work of the Advisory Committee on Corrosion. It is such an excellent summation with notes on current and projected activites that we reprint it for all interested to review.

*1.* Committee B-3 was organized in 1922. Its purpose, as announced in the first report (1923), is "for the purpose of improving the technique of corrosion testing of non-ferrous metals and alloys, of standardizing it so far as possible, and possibly later of assembling standard data on the corrosion resistance of different non-ferrous materials."

*2. Completed Work:*

A. The first project of the Committee was in line with the purpose expressed above. *Cooperative corrosion tests* (14 laboratories) were conducted on a series of companion samples of six non-ferrous metals distributed by the Committee, by four methods—simple immersion, alternate immersion, spray, and accelerated electrolytic. Six solutions were used in each case, 2 acids, 2 alkalies, 2 neutral solutions. The correlated results, published in 1927 (*Proceedings*, Vol. 27), have served as background for the later standardization of these corrosion test procedures.

B. Plans maturing over a period of several years for the study of *corrosion of non-ferrous metals under different conditions of service* culminated in 1931 in the starting of three series of tests: (a) long-time outdoor exposure tests, (b) corrosion in liquids (manufacturers' plant conditions), and (c) galvanic corrosion of coupled metals under outdoor exposure conditions.

(*a*) *Outdoor exposure tests.*—At nine widely separated sites in various parts of the United States exposure tests of projected 20 to 25 years' duration were started on 24 representative non-ferrous metals and alloys. The sites were typical of heavy industrial, light industrial, rural, seacoastal, and inland dry atmospheres. Specimens were of two types, precut tensile bars and 9 by 12-in. sheet. These were to be used for measuring the corrosion rate by progressive change in tensile properties and also by loss of weight and change in surface characteristics. Samples were withdrawn at intervals for testing. The first phase of the work (ten-year period) was finished in 1941, the results being published in the Committee Report of 1943 and 1944. The results of this ten-year test will form the basis of a series of papers to constitute a session at one of the A.S.T.M. meetings. Specimens still remaining on the exposure racks will be allowed to remain there undisturbed for another ten years before the test is terminated.

(*b*) *Corrosion in liquids.*—This series of tests was planned (Old Sub. VII) to be representative of corrosive conditions in manufacturers' plants in a number of common chemical solutions ($H_2SO_4$, HCl, NaOH, NaCl). Many of the materials in these tests were identical with those of (*a*). On account of the unsettled industrial conditions during the depression, the progress of this series was disturbed considerably. However, the tests were completed and the results published (*Proceedings*, Vols. 34, 35 and 38).

(*c*) *Galvanic electrolytic corrosion in atmospheric exposure.*—Materials used were those of (*a*) and typical 2-metal couples were exposed at the same test sites. The final report was published (Sub. VIII) in 1939 (*Proceedings*, Vol. 39).

C. Standard corrosion procedures: The early work described, 2A above, formed the background for a Symposium on Corrosion Testing Procedures sponsored by Committee B-3 in 1937. The complete report (seven papers and discussions) has been published by the Society. It has also culminated in the adoption by the Society of standard procedures for (*a*) simple immersion corrosion test, (*b*) alternate immersion corrosion test, and (*c*) salt spray corrosion (fog) test.

*3. Continuing Corrosion Tests:*

A. The second phase of the long-time outdoor exposure tests of non-ferrous metals in sheet form (2B*a* above) is continuing (Sub. VIII). According to present plans it will not be terminated before 1951.

B. As a supplement to the galvanic electrolytic corrosion (coupled metals) in outdoor exposure (2B*c* above) another series was started in 1941 (Sub. VIII). In this series stainless steel (two types) is coupled with nine selected non-ferrous metals. Three of the exposure sites of the previous series are being utilized, together with a new one (Wilmington, N. C.).

C. *Statistical study* of corrosion data. Use has been made of statistical analysis (Sub. V) in connection with the data of the tests reported under 2B*a*. Use will also be made of the method as new corrosion data are obtained.

*4. Proposed Future Work:*

A. Long-time exposure tests of newly developed non-ferrous alloys are under consideration (Sub. VI) with special consideration being given to aluminum alloys and magnesium alloys for use by the aircraft industry. The tests would be conducted along the same lines as 2B*a* above.

B. A program of galvanic electrolytic corrosion tests with magnesium as one of the coupled metals in cooperation with Committee B-7 has been arranged (Sub. VIII). A very active start on the tests has been made and starting of the tests is expected within a year.

C. *Weather.* A subcommittee (Sub. VII—new) has been formed to study the various elements which make up "weather" and to attempt a "more precise evaluation of those weather factors which influence atmospheric corrosion and a correlation of such factors with the performance of materials under test." The ultimate aim would be to extend the basis for the intelligent application of results of atmospheric exposure tests, particularly in respect to their use in estimating performance of materials at locations other than those at which large scale tests are made.

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## Research and Careers in Mineral Industries

THOSE who would be interested in a discussion of careers in mineral industries may wish to procure from Pennsylvania State College an interesting booklet discussing this subject at some length

### *Science and Technology—A Vital National Resource*

MOST people believe that our national resources consist entirely of the physical appurtenances of the country—the mineral deposits, water power, farm lands, and forests. It can be said that the most important national resource of this or any nation is a state of mind, a spiritual rather than a physical deposit. It is the inquisitive nature of the scientific investigator, using the tools and methods that he has devised, which allows even the most abundant of naturally occurring resources to become national and individual wealth. A nation can have a copious supply of ores, fertile soil, and streams, yet remain in poverty, if widespread technical studies are not continually being carried on to change these natural phenomena of low value to products of increasing usefulness to mankind. The tendency in such a nation is to "mine" the farms and forests and leave the properly available resources relatively untouched. On the other hand, a people who employ the scientific methods of research to the fullest extent could probably become a wealthy nation and enjoy a high standard of living if their only resources were sea water, coal, and sand.

J. C. DEHAVEN,
Battelle Memorial Institute

(See his paper elsewhere in this BULLETIN.)

and also a related circular also available from the School of Mineral Industries at Penn State which covers opportunities for productive work through mineral industries research. Profusely illustrated with pertinent comments, these books would unquestionably be of help to those who are interested in these fields or who have associates who are concerned. The first booklet on Careers can be obtained from the office of Dean Edward Steidle, and the one on Research from Dr. A. W. Gauger.

## Reprints of Townsend and Kettering Addresses

MUCH interest has been evidenced in the addresses of President John R. Townsend and Dr. C. F. Kettering, Vice-President of General Motors Corp., as printed in the December ASTM BULLETIN. Extra copies of the papers have been requested by some who were interested in referring the papers to friends and associates interested in technical and research activities. Reprints of Mr. Townsend's paper are available and the General Motors Research Laboratories have arranged to reprint Dr. Kettering's address and we are advised that they will be glad to send copies on request. Notes to A.S.T.M. Headquarters and General Motors Research will bring the respective reprints.

Cuts courtesy SAE Journal

## More Power to Engineering

THE accompanying condensed excerpts are from a paper presented before the Society of Automotive Engineers, Cleveland Section, in September by J. C. Zeder, Chairman of the Engineering Board, Chrysler Corp. The complete paper, a most interesting one, was published in the November S.A.E. *Journal*. Mr. Zeder has been long affiliated with A.S.T.M. and represents the Sustaining Membership held by the Chrysler Corporation. Mr. Zeder's complete paper has been published by the Chrysler Corp.

Sometimes engineering reports defeat themselves by their very size. A young engineer, who recently gave birth to a Britannica-sized technical epic, asked one of the company's executives if he had read it.

"Read it?" came the answer. "I can hardly *lift* it."

* * *

The average engineering report gives little help to the executive reader whose time is limited. It is hard to find things in it. Indexes are the exception rather than the rule. Careful organization under numerous and explanatory headings is infrequent. Instead of being pointed up and emphasized, important facts and conclusions are frequently buried in a mass of detail.... Charts and curves generally require considerable study to dig out their significance. Photographs or other illustrations often are insufficiently identified.

* * *

No engineer worth his salt would think of prejudging a piece of material or a new device until he had given it a thorough and impartial test. Yet how frequently does he find himself nursing along his own ideas like little hothouse flowers...and pouring cold water on an equally tender sprout of an idea that is sent in from the outside.

Often, people don't seem to understand the engineer's point of view, sympathize with his problems, or appreciate his objectives.... Time and again he is faced with the discouraging fact that nobody seems interested.... Reason: Many times engineers are far from interesting!

* * *

There are two types of engineer: the calm, unemotional, fact-finding scientist.. No one can quarrel with the soundness of his approach. In contrast is the engineer who allows his enthusiasm to run away with his engineering judgment.

The latter does far more harm than good, but the former, striving to avoid the pitfalls of over-enthusiasm often goes too far in the other direction...turns the glasses around and invites people to look through the wrong end.

* * *

Engineering reports act as ambassadors *in absentia* for engineers and engineering departments. Yet, engineers often send them out unmindful of their forbidding countenances, their unkempt appearance, their complicated jargon and their awkward manners. Is it any wonder the engineer's day in court is not always successful?


## New National Directory of Commodity Specifications

THIS extensively revised directory of commodity specifications provides classified and alphabetical lists and brief descriptions of specifications of national recognition. It has been a good many years since a revised directory has been issued and there has been a crying need for it in view of the many new and revised specifications that have been issued by a large number of technical groups, trade associations, and the Government. The directory provides a place for recording *all* specifications of national significance. Prepared by Paul A. Cooley and Ann E. Rapuzzi of the Division of Codes and Specifications, United States Department of Commerce, National Bureau of Standards, it is issued as Miscellaneous Publication M178. Copies can be obtained from the United States Government Printing Office, Washington 25, D. C. at $4 per copy. 1311 pages, page size $7\frac{5}{8}$ by $10\frac{1}{4}$ in.

Because of the widespread reference throughout the book to A.S.T.M. specifications and tests and the fact that the publication will undoubtedly be of great value to so many A.S.T.M. members the following excerpts from the introduction are reprinted since this describes the book quite succinctly:

This publication is a third edition of the National Directory of Commodity Specifications, published first in 1925, and in revised and enlarged form in 1932. In it will be found listed and briefly described the standards and specifications of trade associations, technical societies, and organizations that are representative in a national way of industry or some branch of industry, as well as the standards and specifications of governmental agencies that represent the Federal Government as a whole. Included also are references to the purchase specifications of several departments and establishments of the Federal Government.

As in the previous editions, the decimal system of classification of commodities is used, some minor changes and additions having been made to take care of new material.

The classification system adopted in the Directory tends to group specifications and standards relating to the same subjects, so that specification-making bodies may take note of, or be forwarned concerning duplication of material. Moreover, a special effort has been made to increase the value of the Directory to the purchaser who desires to employ nationally recognized specifications. For example, if the use of a commodity is not self-evident from the title of the specification a brief explanation has been given when possible. A summary of each specification is also included so that the reader may to some extent judge for himself whether the scope of the specification fits his particular needs. Cross referencing serves to tie up related specifications.

Notwithstanding the fact that some of the specifications listed in the Directory will become obsolete in a relatively short time because revised specifications have superseded them, the Directory will lead to up-to-date information if properly utilized. When an issuing agency receives an order for a specification referred to in the Directory, it will supply its current specification unless specifically requested to deliver the one that has been superseded.

#### Excerpts from Article Describing Directory

In the October *Domestic Commerce*, issued by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, Paul A. Cooley who prepared the new national directory has a short interesting article concerning it, and he makes some interesting statements on specifications and standards. Excerpts from this article follow:

SPECIFICATION PURCHASING

To an ever-increasing extent more and more organizations and purchasing agents recognize that the logical way to achieve reasonable economy in purchasing is through the use of dependable specifications. Only through the use of a well-formulated specification giving definite, concise, and complete statements of information can the buyer accurately present his needs to the seller. This provides a system whereby both production and distribution can be coordinated to their mutual benefit in supplying the needs of the user.

The Federal Government was a pioneer in purchasing under specifications. For many years efforts have been made to perfect this system of buying by continually revising old specifications to meet new and changing demands and by adding an ever-increasing number of new specifications covering commodities never before purchased by specification. By this process real competitive bidding can be invited and the delivery of satisfactory material can be required. Public purchasers as a whole are desirous of obtaining the maximum benefits for the public funds expended.

Many years ago certain progressive purchasing officials for states, municipalities, and public institutions began to follow the basic procedure of the Federal Government in utilizing well-recognized standard specifications. Today this procedure is followed by practically all public purchasing officials as an integral part of their official duties. The intense competition in the modern business world during the last few decades has made it necessary also for the efficient purchasing official of a successful industrial organization to avail himself of the advantages of specification buying.

STANDARDS ARE VITAL

Commodity standards in the form of standard specifications such as are listed in the directory—standards of quality, uniformity, dimension, performance, utility, and duration—are an aid to ethical conduct in the modern business and industrial world. As a logical sequence, they lead to a well-balanced economy in which the producer, distributor, and consumer may have fair and equal protection.

Well-directed scientific investigation is a necessary foundation for commodity standards, which are the result of a never-ending process of refinement due to continued change, advancement, and the introduction of new products. Proper standards necessitate the true cooperation of the representatives of the producer, distributor, and consumer in an effort to produce a practical standard applicable to current conditions. Every important standard, when established by wide usage, leads to a tremendous saving in production, saving in routine business transactions, and elimination of the greatest of all waste, that of the failure of the commodity to do what is expected of it.

The great number of standards listed in the directory is evidence of the extent to which they have become an aid to executives and technicians in controlling industries and commercial enterprises. Suitable, accurate, and simplified methods of testing, by which the exact quality of the product can be determined beyond question, form one type of these standards.

Simplification is another development which accounts for many of the items included. This eliminates a vast amount of unnecessary varieties, leaving fewer and simpler types with greater utility. Fewer varieties, in turn, eliminate vast wastes in production and distribution, lead to increased demands and stimulate mass production, lowered prices, and stabilized production with incalculable benefit to producer, distributor, and consumer.

AMERICAN STANDARDIZATION

Fortunately, America has pioneered in standardization, which may have much to do with the fact that today we lead the world as an industrial nation. Some work had been done along this line before World War I. At that time American industries, in turning to war production, found it necessary to correct many conditions caused by insufficient standardization. This was among the prime reasons why standardization was greatly accelerated after the war.

In recent years, when America had no alternative except to absorb the shock of sudden war, our highly mechanized, modern industry as a whole came to the rescue and was quickly diverted to war production. As in World War I industry found that it was, although to a very much less extent, handicapped and delayed because of insufficient attention to standardization in the prewar era. A much accelerated and broader program of standardization will be extremely beneficial during peacetime production, and should another national emergency arise it will be of immeasurable value.

## Information on Seized Patents—Libraries Have Abstracts and Complete Documents

THE 33,000 United States patents and patent applications which the Alien Property Custodian seized from enemy owners during the war are being licensed at an accelerating rate since V-J day, to American citizens who are looking for new products, processes, and improvements. Many of these inventions cover measuring and testing apparatus and equipment, and should be of interest to members of the A.S.T.M. Over 7400 different patents have already been licensed to nearly 900 different firms and individuals.

The abstracts of these patents which the Custodian has published greatly facilitate searching for useful inventions. A description and price list may be obtained from any of the Alien Property Custodian patent libraries located in the following cities:

| | |
|---|---|
| Washington 25, D. C. National Press Bldg. 14th and F Sts. | New York 5, N. Y. 120 Broadway |
| | Boston 8, Mass. 1 Court St. |
| Chicago 3, Ill. Field Bldg. 135 South La-Salle St. | Los Angeles, Calif. Public Library |

A library of vested patents has also been deposited at the Midwest Research Institute, 4049 Pennsylvania, Kansas City, Mo. Complete files of the vested patents arranged according to some 300 Patent Office classes, as well as patent abstracts and subject lists of patents are available for inspection at these libraries.

The following Public Libraries receive copies of *all* United States patents as issued (filing them numerically) and of the patent abstracts published by the Custodian:

| | |
|---|---|
| Los Angeles, Calif. | Cincinnati, Ohio |
| Chicago, Ill. | Cleveland, Ohio |
| Boston, Mass. | Columbus, Ohio |
| Detroit, Mich. | Toledo, Ohio |
| St. Louis, Mo. | Philadelphia, Pa. (Franklin Institute) |
| Newark, N. J. | |
| Albany, N. Y. (State Department of Education) | Pittsburgh, Pa. (Carnegie Library) |
| Buffalo, N. Y. (Grosvenor Library) | Providence, R. I. |
| New York, N. Y. | Madison, Wis. (State Historical Society) |

Of special interest to members of the A.S.T.M. should be the abstracts of the following classes, the prices of which are indicated in parentheses:

236 Automatic temperature and humidity regulation (10c)
249 Automatic weighers (10c)
23 Chemistry (for chemical laboratory equipment) (10c)
265 Force measuring (10c)
33 Geometrical instruments (25c)
58 Horology (10c)
73 Measuring and testing (25c)
83 Mills (25c)
88 Optics (10c)
234 Recorders (10c)
235 Registers (25c)
297 Thermostats and humidostats (10c)
116 Signals and indicators (10c)
161 Time controlling mechanism (10c)

Orders for these abstracts should be sent with remittance to the Office of Alien Property Custodian, Chicago 3, Ill. Checks should be made payable to "Alien Property Custodian."

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## Advance Distribution of 1946 Preprints of Papers

NOTE.—The five papers listed below have been preprinted for immediate distribution in accordance with the new policy of the Society of preprinting papers as they become available throughout the year. Abstracts of these papers appear on p. 59 of this BULLETIN.

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| ____ | A 2 | A Study of the Geometry of the Tension-Impact Specimen—N. A. Kahn and E. A. Imbembo. |
| ____ | A 3 | Calculation of Electrical Contacts under Ideal Conditions—Erle I. Shobert II. |
| ____ | A 4 | The Influence of Gypsum on the Hydration and Properties of Portland Cement Pastes—William Lerch. |
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### Calendar of Society Meetings

(Arranged in Chronological Order)

AMERICAN CONCRETE INSTITUTE—Forty-second Annual Convention, February 18–21, Hotel Statler, Buffalo, N. Y.

**American Society for Testing Materials**—Spring Meeting and Committee Week, February 25–March 1, Hotel William Penn, Pittsburgh, Pa.; Annual Meeting and Exhibit of Testing Apparatus and Related Equipment, June 24–28, Buffalo, N. Y.

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY—National Meeting, February 25–28, New York, N. Y.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—Annual Meeting, February 25–28, Chicago, Ill.

TWENTIETH EXPOSITION OF CHEMICAL INDUSTRIES—February 25–March 2, Grand Central Palace, New York, N. Y.

AMERICAN RAILWAY ENGINEERING ASSOCIATION—March 12–14, Palmer House, Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Spring Meeting, April 1–3, Hotel Patten and Reid House, Chattanooga, Tenn.; Semi-Annual Meeting, June 17–20, Detroit, Mich.

MIDWEST POWER CONFERENCE—April 3–5, under sponsorship of Illinois Institute of Technology and other Schools, Chicago, Ill.

SAE NATIONAL AERONAUTICAL MEETING—April 3–5, Hotel New Yorker, New York, N. Y.

AMERICAN SOCIETY OF TOOL ENGINEERS—Annual Meeting and Exposition, April 8–12, Public Auditorium, Cleveland, Ohio.

AMERICAN CHEMICAL SOCIETY—109th Meeting, April 8–12, Atlantic City, N. J.

ELECTROCHEMICAL SOCIETY—Spring Congress, April 11–13, Birmingham, Ala.

Twenty-ninth Annual Open-Hearth Steel and Blast Furnace and Raw Materials Conferences, April 25–26, Chicago, Ill.

AMERICAN CERAMIC SOCIETY—Forty-eighth Annual Meeting, April 28–May 1, Hotel Statler, Buffalo, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION—Fiftieth Annual Foundry Congress and Show, May 6–10, Public Auditorium, Cleveland, Ohio.

AMERICAN IRON AND STEEL INSTITUTE—Fifty-fourth General Meeting, May 23, Waldorf-Astoria Hotel, New York, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION—Fifty-third Annual Meeting, June 20–23, Jefferson Hotel, St. Louis, Mo.

NATIONAL INSTITUTE OF GOVERNMENTAL PURCHASING—Annual Conference and Products Exhibit, August 19–21, Hotel Stevens, Chicago, Ill.

# NEW MEMBERS TO JANUARY 17, 1946

The following 119 members were elected from November 21, 1945 to January 17, 1946:

### Chicago District

Central Die Casting and Manufacturing Co., Inc., L. J. Sebek, President, 2935 W. Forty-seventh St., Chicago 32, Ill.

Farnam Co., F. D., R. G. Farnam, President, 4940 W. Flournoy St., Chicago 44, Ill.

Great Lakes Carbon Corp., R. W. Morgan, Chief Engineer, 333 N. Michigan Ave., Chicago 1, Ill.

Harley-Davidson Motor Co., William J. Harley, Chief Engineer and Treasurer, 3700 W. Juneau Ave., Milwaukee 1, Wis.

Kyle Corp., A. Van Ryan, Chief Engineer, South Milwaukee, Wis.

Engle, James F., Metallurgist, Webster-Chicago Corp., Chicago, Ill. For mail: 5919 N. Kostner Ave., Chicago 30, Ill.

McGrane, Donald C., Supervisor, Engineering Inspection, U. S. Navy Dept., South Bend, Ind. For mail: 542 N. Scott St., South Bend 16, Ind.

Pierce, E. W., Chief Metallurgist, Carnegie-Illinois Steel Corp., 3426 E. Eighty-ninth St., Chicago 17, Ill.

Rader, Louis T., Director, Department of Electrical Engineering, Illinois Institute of Technology, 3300 S. Federal St., Chicago 16, Ill.

Schroeder, Fred J., Jr., Treasurer, Milwaukee Die Casting Co., 1015 N. Fourth St., Milwaukee 3, Wis.

Smith, L. H., Vice-President in Charge of Engineering, General American Aerocoach Co., 136th St. and Brandon Ave., Chicago 33, Ill.

### Cleveland District

Geib, Ervin R., Arc Department Manager, National Carbon Co., Inc., Box 6087, Cleveland 1, Ohio.

Groves, Karl, Materials Engineer, Apex Electrical Manufacturing Co., E. 136th St. and Kuhlman Ave., Cleveland 10, Ohio.

Mueller, Fred R., Manager and Package Director, Cozier Wood Package Co., 1196 E. 152d St., Cleveland 10, Ohio.

### Detroit District

Textileather Corp., John A. Weber, Plant Chemist, Wayne Bldg., 607 Madison Ave., Toledo 4, Ohio.

Caplan, Samuel J., Chemist, Peerless Chemical Co., 3850 Oakman Blvd., Detroit 4, Mich. For mail: 225 Merton Rd., Detroit 3, Mich.

Kelly, Fred J., Wilcox-Rich Division, Eaton Manufacturing Co., 9771 French Rd., Detroit 13, Mich.

### New York District

American Isteg Steel Corp., Joseph Mercadante, President, 120 Broadway, New York 5, N. Y.

American Petroleum Inst., D. V. Stroop, Assistant to President, 50 W. Fiftieth St., New York 20, N. Y.

Casco Products Corp., Carl Schaefer, Chief Chemist, 512 Hancock Ave., Bridgeport 2, Conn.

Cohn and Co., Sigmund, 44 Gold St., New York 7, N. Y.

Drew and Co., Inc., E. F., Richard C. Ulmer, Technical Director, Industrial Dept., 15 E. Twenty-sixth St., New York 10, N. Y.

General Aniline and Film Corp., Calvin E. Schildknecht, Chemist, 247 Park Ave., New York 17, N. Y.

Hanson-Van Winkle-Munning Co., Myron B. Diggin, Chief Chemist, Church St., Matawan, N. J.

Jefferson Chemical Co., Inc., Max Neuhaus, Director of Research, 30 Rockefeller Plaza, New York 20, N. Y.

Miller & Weber, R. M. Wilhelm, Sales Manager, 71-14 Myrtle Ave., Glendale, L. I., N. Y.

New York Laboratory Supply Co., Inc., M. Resnick, President, 78 Varick St., New York 13, N. Y.

Pitney-Bowes, Inc., Walter A. Raymond, Metallurgist, Walnut and Pacific Sts., Stamford, Conn.

Wallace & Tiernan Co., Inc., R. B. Martin, Manager, Industrial Div., Box 178, Newark 1, N. J.

Corbett, Edwin E., Division Sales Manager, Portable Products Corp., C. J. Tagliabue Division, 550 Park Ave., Brooklyn 5, N. Y.

Frauenfelder, Herman, Managing Director, The Cast Stone Inst., Box 606, New Haven 3, Conn.

Friedland, Samuel, Sales Manager, Nurnberg Thermometer Co., Inc., 124 Livingston St., Brooklyn 2, N. Y.

Garber, Samuel, Graduate Student, New York University, University Heights, New York 53, N. Y. For mail: 1840 Belmont Ave., Bronx 57, N. Y. [J]*

Greenberg, Sherman, Chemist, Metasap Chemical Co., Harrison, N. J. For mail: 199 Patchen Ave., Brooklyn 33, N. Y. [J]

Haltenhof, Harold R., Draftsman, The Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y. For mail: 700 E. 141st St., New York 54, N. Y. [J]

Hatch, Herbert H., Director, Hatch Textile Research, 25 E. Twenty-sixth St., New York 10, N. Y.

Hibbard, Walter R., Jr., Assistant Professor of Metallurgy, Hammond Metallurgical Laboratory, Yale University, New Haven, Conn. For mail: 14 Mansfield St., New Haven, Conn.

Laine, David, Secretary, American Die Casting Inst., Inc., 366 Madison Ave., New York 17, N. Y.

Mayer, William F., Senior Chemist, Centro Research Laboratories, 855 Meeker Ave., Brooklyn, N. Y. For mail: 9521 Eighty-fifth St., Ozone Park, N. Y.

Reich, Ismar M., Chemical Engineer, Standard Brands, Inc., Fleischman Laboratories, 810 Grand Concourse, Bronx 51, N. Y. For mail: 710 Riverside Dr., New York 31, N. Y. [J]

Reich, Leo, Analytical and Control Chemist, Wyeth, Inc., 1106 Harrison Ave., Kearny, N. J. For mail: 665 New Jersey Ave., Brooklyn 7, N. Y. [J]

Sachs, Bruno, Production Manager, Dollin Corp., 600 S. Twenty-first St., Irvington, N. J.

Strauss, Harry L., Jr., President, National Diamond Hone and Wheel Co., 108 Fulton St., New York 7, N. Y. For mail: 23 W. Seventy-third St., New York 23, N. Y. [J]

Thurn, Russell E., Senior Chemical Engineer, Barber Asphalt Corp., Barber, N. J.

Worden, Edwin S., Jr., Research Engineer, Edgar Steiner and Co., 45 Rockefeller Plaza, New York 20, N. Y.

### Northern California District

Pitman, Gilbert A., Vice-President and Manager, Container Testing Laboratories, Inc., 151 New Montgomery St., San Francisco 5, Calif.

Twining, Frederick Wolverton, Managing Director, The Twining Laboratories, Box 1472, Fresno, Calif.

### Philadelphia District

Asbestos Cement Products Assn., Donald Tulloch, Jr., Manager, 17th Fl., Inquirer Bldg., Philadelphia 30, Pa.

Biddle Co., James G., H. A. Eysenbach, Engineer, 1211 Arch St., Philadelphia 7, Pa.

Publicker Industries, Inc., Nathan Lacktman, Chief Control Chemist, Delaware Ave. and Bigler St., Philadelphia, Pa.

Engstrom, J. Emil, Quality Control Engineer, Arcos Corp., 1515 Locust St., Philadelphia 2, Pa.

McKee, James, Jr., Foreman, Sun Oil Co., Marcus Hook, Pa.

Shull, Dean E., Jr., Ensign, USNR. For mail: 714 Blythe Ave., Drexel Hill, Pa. [J]

Westwater, J. W., Research Fellow, Division of Chemical Engineering, University of Delaware, Newark, Del. [J]

### Pittsburgh District

Wyckoff Steel Co., H. M. Smith, Chief Metallurgist, Ambridge, Pa.

Carapella, Louis A., Metallurgist, Mellon Institute of Industrial Research, Pittsburgh 13, Pa.

Cox, Alfred M., Metallurgical Engineer, Pittsburgh Commercial Heat Treating Co., Forty-ninth and A.V.R.R., Pittsburgh, Pa. For mail: 2225 William Penn Highway, Wilkinsburg, Pa.

Dunn, Edward J., Chief Chemist, Duquesne Works, Carnegie-Illinois Steel Corp., Duquesne, Pa.

Hedrick, Robert H., Chemical Engineer, Gulf Research and Development Co., Box 2038, Pittsburgh, Pa. For mail: 521 Second St., Verona, Pa. [J]

McGervey, W. J., Manager, Sheet and Strip Bureau, Metallurgical Division, Carnegie-Illinois Steel Corp., Frick Building Annex, Pittsburgh 30, Pa.

Rodecker, L. A., Chief Specification Examiner, Alloy Bureau, Metallurgical Div., Carnegie-Illinois Steel Corp., 434 Fifth Ave., Pittsburgh 30, Pa.

Russell, Ralston, Jr., Director of Ceramic Research, Westinghouse Electric Corp., Westinghouse Research Laboratories, East Pittsburgh, Pa.

Wang, Si-Chi, Technician, Ministry of Communications, China. For mail: c/o B. W. Capron, Employment Manager, The Cooper Bessemer Corp., Grove City, Pa.

### St. Louis District

Russell & Axon, Consulting Engineers, F. E. Wenger, Administrative Engineer, Room 317, 6635 Delmar Blvd., St. Louis 5, Mo.

Sussenbach, Paul S., Director of Research and Chief Chemist, Presstite Engineering Co., 3900 Chouteau Ave., St. Louis 10, Mo.

### Southern California District

Erick, Murray, Consulting Engineer, Murray Erick Associates, 811 W. Seventh St., Los Angeles 14, Calif.

Hall, Earl B., Materials Engineer, U. S. Engineer Office, Los Angeles, Calif. For mail. 624 Locust St., Norwalk, Conn.

Pacific Aeronautical Library of the Institute of Aeronautical Sciences, 6715 Hollywood Blvd., Hollywood 28, Calif.

Schroder, Howard, Architect, 14347 Riverside Dr., Van Nuys, Calif.

### Western New York-Ontario District

Harrisons & Crosfield (Canada), Ltd., Technical Division, Cecil H. Wastle, Chief Chemist, 240 Adelaide St., West, Toronto 1, Ont., Canada.

Mathieson Alkali Works, Inc., G. D. Byrkit, Patent and Library Supervisor, Niagara Falls, N. Y.

Mayer, Joseph J., General Superintendent, Lumen Bearing Co., 197 Lathrop St., Buffalo 12, N. Y.

Monier, J. B., Research Chemist, Synthetic Resins, Ltd., Galt, Ont., Canada.

Schoch, Milton G., Jr., Superintendent, Quality Control, Hewitt Rubber Corp., 240 Kensington Ave., Buffalo 5, N. Y.

Wernimont, Grant, Senior Physicist and Chemist, Eastman Kodak Co., Industrial Lab., Bldg. 23, Kodak Park, Rochester 4, N. Y.

Windle, Maurice L., Chief Chemist, Simonds Saw and Steel Co., Lockport, N. Y.

### U. S. and Possessions

Anderson Manufacturing Co., Albert & J. M., W. B. Pearce, Chief Engineer, 289 A St., Boston 10, Mass.

Bendix Radio, Division of Bendix Aviation Corp., G. R. White, Section Chief,

Measurements and Standards Engineering, Towson 4, Md.

DUTTON-LAINSON Co., Hal Lainson, Factory Manager, Hastings, Nebr.

FARGO MANUFACTURING Co., R. B. Schoonmaker, Development Engineer, 939 Main St., Poughkeepsie, N. Y.

HARTFORD MACHINE SCREW Co., John J. Kihm, Production Engineer, 476 Capitol Ave., Hartford, Conn.

HOLLINGSWORTH & WHITNEY Co., John L. Parsons, Research Director, Waterville, Me.

HOWE & FRENCH, INC., M. E. Nourse, Manager, Laboratory Division, 99 Broad St., Boston 10, Mass.

LAKE SHORE TIRE AND RUBBER Co., G. L. Mochel, Fabric Division, Des Moines 6, Iowa.

LAN-O-SHEEN Co., Edward B. Lampman, Production Manager, 804 Finch Bldg., St. Paul 1, Minn.

NEW ENGLAND COLLAPSIBLE TUBE Co., 170 Broad St., New London, Conn.

PLAX CORP., James Bailey, Vice-President and Research Director, Box 1019, Hartford, Conn.

SHEAFFER PEN Co., W. A., C. H. Lindlsy, Manager, Testing Labs., Ft. Madison, Iowa.

WESTERN GEAR WORKS, Leon Olberg, Metallurgist, 417 Ninth Ave., S. Seattle 4, Wash.

WIRE REINFORCEMENT INST., T. J. Kauer, Managing Director, 1049 National Press Bldg., Washington 4, D. C.

ALEXANDER, M. DAVIS, Specification Writer, 2306 Crawford St., Houston 4, Tex.

BACH, A. DUDLEY, President, New England Metallurgical Corp., 9 Alger St., S. Boston, Mass.

BROWN, PAUL N., Chief Chemist, Morgantown Coal Testing Laboratory, 240 Steward St., Morgantown, W. Va. For mail: 205 Rotary St., Morgantown, W. Va.

BROWNING, LAWRENCE R., Testing Engineer, The Haller Engineering Associates, Inc., Boston, Mass. For mail: Box 227, Norwich, Conn.

CANN, R. J., Lieutenant Colonel, French Embassy, 1759 R St., N. W., Washington 9, D. C.

EYNON, HOWARD B., President, Pure Carbon Co., Inc., St. Marys, Pa.

FRANKLIN, STANLEY H., Chemical Engineer, Fram Corp., E. Providence, R. I. For mail: 85 Hoyt Ave., Rumford 16, R. I.

HAYNES, HILLIARD G., Associate Professor of Civil Engineering, The Citadel, Charleston, S. C.

KAUFMANN, CARL P., Chief Engineer, Ellicott Machine Corp., 1611 Bush St., Baltimore 30, Md.

KENDALL, EDGAR R., Materials Engineer, U. S. Army Engineers, 1709 Jackson St., Omaha 2, Nebr. For mail: 2879 Bauman St., Omaha 11, Nebr.

LEARNED, DON R., Ensign, USNR. For mail: 187 Common St., Belmont 78, Mass. [J]

LIPSCHITZ, LEON, Private, Corps of Engineers, U. S. Army. For mail: 450 South St., Pittsfield, Mass. [J]

MILLER, FORREST E., Associate Professor, University of Minnesota, 206 Experimental Engineering Bldg., Minneapolis 14, Minn.

POTTS, ROBERT J., Engineer-Consultant, 1412 Amicable Bldg., Waco, Tex.

REICH, WILLIAM A., Metallurgical Engineer, General Electric Co., Works Laboratory, Schenectady 5, N. Y.

SEYMOUR, RAYMOND B., Director, Industrial Research Inst., University of Chattanooga, Chattanooga 3, Tenn.

SWEENEY, EDMOND L., Superintendent, Everett Plant, Boston Consolidated Gas Co., Rover St., Everett, Mass.

WOOD, J. ELDRIDGE, Materials Engineer, Maryland State Roads Commission, 647 W. Redwood St., Baltimore 1, Md.

### Other than U. S. Possessions

COMPAÑÍA ANÓNIMA LA CONCRETERA, Augusto Guinand, President, Carretera el Valle Kilometro 3, Caracas, Venezuela.

PRODUCTOS INDUSTRIALES, S.A. A. D. Nagel, Manager, Prado Norte No. 115, Lomas de Chapultepec, Mexico, D. F., Mexico.

SOUTH AFRICAN IRON AND STEEL INDUSTRIAL CORP., LTD., J. E. K. Tucker, Secretary, Box 450, Pretoria, South Africa.

SVERIGES STANDARDISERINGSKOMMISSION, Folke Lindgren, Engineer, Brunkebergstorg 12, 3 tr., Stockholm, Sweden.

SWEDISH CEMENT AND CONCRETE RESEARCH INST., THE, Georg Wästlund, Professor, The Royal Technical University, Stockholm, Sweden.

ÅRMANN, NILS, Managing Director, Björneborgs Jernverks Aktiebolag, Björneborg, Sweden.

ERIK, ALBERT BACKLUND, Civil Engineer, Royal Swedish Telegraph and Telephone Administration, Telegrafverkets Verkstand, Nynäshamn, Sweden.

HÅKANSON, PER SIGURD, Chief Chemist, Skånska Cement AB, Malmo, Sweden. For mail: Cement- och Betonglaboratoriet, Limhamn, Sweden.

JOCHEM, JEAN, Refinery Superintendent, Iraq Petroleum Co., Haiffa, Palestine. For mail: Tripoli Refinery, Tripoli, Syria.

LUNDBERG, BO KLAS OSKAR, Chief of Structural Dept., The Aeronautical Research Institute of Sweden, Ulusanda, Sweden.

REIS, THOMAS, Research Engineer, Compagnie Française de Raffinage, Paris, France. For mail: 24 Rue d'Alesia, Paris XIVème, France.

TODD, ALLEN D., Junior Chemist, Electric Reduction Co. of Canada, Ltd., Burkingham, P. Q., Canada. [J]

* [J]—Denotes Junior Member.

# Personals . . .

*. . . News items concerning the activities of our members will be welcomed for inclusion in this column.*

ARTHUR CLYDE CRAWSHAW, formerly Coordinator, Plans and Specifications, Holmes & Narver, Los Angeles, Calif., is now with the McNeil Construction Co., Los Angeles.

B. L. AVERBACH is now Research Assistant, Massachusetts Institute of Technology, Cambridge, Mass. He was Metallurgical Engineer, General Electric Co., Schenectady, N. Y.

H. N. CEDERGREN, who was formerly Metallurgist, Aluminum Foundry, North American Aviation, Inc., Grand Prairie, Texas, has been building his own plant to process and make non-ferrous specification metals and metal products. The plant started operation as of January 1, 1946. The name of the company is Cedergren Metals Co.; it's located in Dallas, Texas, and Mr. Cedergren's title is Metallurgical Engineer and Owner.

JEROME VEGOSEN, formerly Draftsman-Engineer, Consolidated Machine and Design Co., Inc., New York, N. Y., is now Test Engineer, Wright Aeronautical Corp., Paterson, N. J.

THOMAS JAMES DOLAN has been released from active duty with Army Ordnance Department after three years and has returned to his former civilian position as Research Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

BOYD CHRISTENSEN, who was General Foreman, Tool Engineer, Boeing Airplane Co., Wichita Division, Wichita, Kansas, is now Junior in Mechanical Engineering, University of Oklahoma, Norman, Okla.

DAVID V. STROOP, who has been Director of the Department of Engineering, American Petroleum Institute, has been appointed Assistant to the President, this new office having been established by the Board of Directors recently. Mr. Stroop has been very active in A.S.T.M. and is serving as the Secretary of Committee D-2 on Petroleum Products and Lubricants. Associated with the A.P.I. since 1928, he has had a number of responsibilities, including secretaryship of the A.P.I. Division of Marketing, and entered the Department of Accident Prevention, and more recently has been Secretary of the Division of Refining. A graduate of George Washington University with a degree of B.S. in C.E., he later received his L.L.B. from the New York Law School. His son, a captain, served throughout the war in Africa and the European theater, while his daughter is a senior at Antioch College.

HERBERT F. SCOBIE, formerly Foundry Instructor and Consultant, Mechanical Engineering Department, University of Minnesota, Minneapolis, Minn., recently joined the staff of the American Foundrymen's Association in Chicago. Leaving the University where he taught foundry practice for six years and chemistry for one year, he will assist in the coordination and development of the A.F.A. educational program. While at the University, Mr. Scobie prepared sixteen publications and spoke before a number of technical societies. During the war he was Metallurgical Consultant for fifteen companies in Minnesota and Wisconsin for varying periods of time.

WILLIAM S. CARVER, formerly Sales Engineer, Baldwin-Southwark Division, The Baldwin Locomotive Works, Philadelphia, Pa., is now Sales Engineer for Fred S. Carver, New York, N. Y.

JACK D. TOWERY is now Textile Engineer, Applications Division, Institute of Textile Technology, Charlottesville, Va. He was formerly Research Textile Engineer, National Cotton Council of America, Austin, Texas.

ROGERS B. FINSH, formerly Officer in Charge, Textiles and Textile Products Section, Engineering Division, Jeffersonville Quartermaster Depot, Jeffersonville, Ind., is now with the Textile Division, Massachusetts Institute of Technology, Cambridge, Mass.

GEORGE C. ERNST is now Associate Professor of Civil Engineering, University of Nebraska, Lincoln, Nebr. He was Senior Engineer, U. S. Forest Products Laboratory, Madison, Wis.

J. J. HIGGINS, who served as a Second Lieutenant in the U. S. Army Engineers during the war years, has returned to Massillon, Ohio, as a Chemical Engineer.

B. S. BERTOLET, formerly Senior Electronics Engineer, Electronics Laboratory, Baldwin Locomotive Works, Eddystone, Pa., is now Condensing Unit Design

Engineer, Refrigeration Division, Electric Power Equipment Corp., Philadelphia, Pa.

A. H. EDGERLY is now Secretary and Treasurer, Edgerly Instrument Laboratories, Inc., Baltimore, Md. He was Instrument Engineer, Alvin S. Mancib Co., West Somerville, Mass.

A. A. DUKERT, formerly Chief Inspector, Plastic Manufacturers, Inc., Stamford, Conn., has been assigned to establishing Material and Equipment Standards for Maintenance, Corporation Engineering Department, American Viscose Corp., Philadelphia, Pa.

HERMAN A. BOGEHOLD, formerly Assistant Manager, Production, Industrial Minerals, Ltd., Waterways, Ontario, Canada, is now Consulting Chemical Engineer, Companhia Itatig, Rio de Janeiro, Brazil.

CARL A. HEDREEN is now connected with Cia. Wilbur-Ellis Peruana, S. A., Lima, Peru. He was formerly Manager, Ocean Industries Laboratory, South San Francisco, Calif.

HAROLD R. ALLEY, who was Associate Research Director, Research and Development Department, Standard Cap and Seal Corp., Chicago, Ill., is now Director of Research, Arvey Corp., Chicago, Ill.

THOMAS C. TWEEDIE, formerly Metallurgist, Douglas Aircraft Co., Inc., Tulsa, Okla., is now Field Engineer, Oil Well Supply Co., Houston, Texas.

WILLIAM G. GROVE was Consultant on Bridges, U. S. Engineer Board, Fort Belvoir, Va. He is now Engineer of Bridges and Structures, Connecticut State Highway Department, Hartford, Conn.

W. E. MAHIN is now Chairman, Metals and Minerals Division, Armour Research Foundation, Technology Center, Chicago 16, Ill. He was Manager, Metallurgical Engineering, Materials Engineering Department, Westinghouse Electric Corp., East Pittsburgh, Pa.

J. PAYNE KING, formerly Chief Inspector, The Lincoln Electric Co., Cleveland, Ohio, is now Treasurer, Alfred B. King and Co., New Haven, Conn.

ALAN F. SHEPARDSON who was Industrial Specialist, Plastics Section, Chemicals Division, War Production Board, Washington, D. C., is now with the Industry Division, OMGUS, APO 742, New York, N. Y.

R. D. LANDON is now Dean of the College of Engineering, The University of Akron, Akron, Ohio. He was formerly Professor of Civil Engineering, Southern Methodist University, Dallas, Texas.

PAUL A. BECK, formerly Head of Metallurgical Laboratory, The Cleveland Graphite Bronze Co., Cleveland, Ohio, is now Associate Professor of Metallurgy, University of Notre Dame, Notre Dame, Ind.

RANDALL C. SMITH, formerly Materials Engineer, Curtiss-Wright Corp., Buffalo, N. Y., is now Unit Head, Structures Department, Curtiss-Wright Corp., Columbus, Ohio.

ROBERT T. SHEEN is now Consulting Chemical Engineer, Philadelphia, Pa. He was Technical Director, W. H. & L. D. Betz, Philadelphia, Pa., whose employ he has left, but is being retained by them as a Consulting Engineer. He is also doing consulting work for Milton Roy Pumps. He is active in the Society's work on industrial waters.

JOHN R. KAUFFMAN has returned to civilian life, having been a Lieutenant, U. S. Naval Reserve, Ordnance Volunteer Specialist, and is now with Allied Engineering Co., Division of Ferro Enamel Corp., Milltown, N. J., as Eastern Representative.

EDWARD S. FRASER has returned from duty with the U. S. Army Air Forces as Captain, to become Engineer, Chicago Bridge and Iron Co., Chicago, Ill.

A. H. NUCKOLLS has retired as Chemical Engineer, but has been retained by Underwriters' Laboratories, Inc., on a part-time basis as a consultant to the staff on technical matters. He plans to do a limited amount of consulting work, particularly in the field of explosion prevention. Mr. Nuckolls has represented the Underwriters' Laboratories membership in A.S.T.M. since 1914 and participated actively in the work of several A.S.T.M. committees.

DANIEL S. EPPELSHEIMER, formerly Research Professor of Industrial Engineering and Acting Director, Engineering Experiment Station, University of New Hampshire, Durham, N. H., is now Sales Manager and Chief Physical Metallurgist, Metal Hydrides, Inc., Beverly, Mass.

ROLF H. EHRMANN is now Research Chemist, U. S. Stoneware Co., Ravenna, Ohio. He was Research Chemist, Elmhurst, L. I., N. Y.

MICHAEL BOCK, II, formerly Metallurgist, Materials Laboratory, U. S. Navy Yard, Boston, Mass., is now Metallurgical Engineer, The Unexcelled Manufacturing Co., Cambridge, Mass.

JOSEPH MAZIA is now connected with the American Chemical Paint Co., Ambler, Pa., as Metallurgist, Metal Surface Treatment Division. He was Head of the Protective Finishes Section of the Ordnance Research Laboratory, Frankford Arsenal, Philadelphia, Pa.

D. F. MURPHY, who was Chief Metallurgical Engineer, Struthers-Wells Corp., Titusville, Pa., is now with the Besser Manufacturing Co., Alpena, Mich., as Chief Metallurgical Engineer.

FRED J. TOBIAS, formerly Vice-President, A.R.D. Corp., New York, N. Y., is now Plant Manager, Advance Pressure Castings, Inc., Brooklyn, N. Y.

ANTHONY SKETT, who was connected with R.B.H. Dispersions, Inc., Bound Brook, N. J., is now with the Industrial Department, W. R. Grace and Co., New York, N. Y.

M. M. BECKWITH, following his release from the Army in December, has accepted a position with The Harshaw Chemical Co., Cleveland, Ohio.

C. C. HENNING, formerly General Metallurgist, Jones & Laughlin Steel Corp., Pittsburgh, Pa., is now Manager of Raw Materials for J and L.

CHARLES D. TOWNSEND, formerly Chief Project Engineer, The S. K. Wellman Co., Cleveland, Ohio, is now Plant Engineer for this company.

THOMAS F. DAVIS, who was Metallurgical Engineer, General Electric Co., Philadelphia, Pa., is now District Manager, The Beryllium Corp., New York, N. Y.

FREDERICK S. BACON who was a Consulting Chemist in Watertown, Mass., is now Chemical Research Consultant, Frederick S. Bacon Laboratories, 192 Pleasant St., Watertown 72, Mass.

RALPH SMILLIE, formerly Engineer of Tests, The Port of New York Authority, New York, N. Y., is now New York City Tunnel Authority, New York, N. Y.

HARRY L. CAMPBELL is now connected with Western Foundries, Chicago, Ill., as Metallurgist. He was formerly a metallurgical engineer in Grand Rapids, Mich.

CECIL W. ARMSTRONG, General Manager of the Armstrong Plastic Co., is moving his office from 666 Lake Shore Drive, Chicago, Ill., to Warsaw, Ind., where his company has acquired factory space and facilities for manufacture of low-pressure laminated plastic products.

O. H. BISHOP has been transferred from Chief Production Engineer, Reynolds Corp., U. S. Naval Ordnance, Macon, Ga., to Assistant Process Director, Reynolds Metals Co., Harrison, N. J.

INSTITUTO URUGUAYO DE NORMAS TECNICAS (The Uruguayan Institute of Technical Standards), a member of A.S.T.M., has announced that Engineer Juan P. Molfino will be president through 1948; Engineer Julio Laporte and Architect Juiio C. Bauza will be first and second vice-presidents, respectively; and secretary, Engineer Julio Ricaldoni, whose term extends through 1947.

H. S. MATTIMORE, who formerly was Materials Engineer, Pennsylvania State Highway Department, and who for some time has been Senior Engineer in the Public Works Department of the U. S. Navy, has announced the establishment of Consulting Service in Concrete Construction, Highway and Airport Pavements, Materials and Research Planning, Specifications, Investigations and Reports. His headquarters are at 4226 Elmerton Ave., Colonial Park, Pa., a Harrisburg suburb. Mr. Mattimore has been very active in A.S.T.M. technical committee work, and is a former member of the Executive Committee.

LOUIS W. KEMPF, formerly Metallurgical Research Engineer, has been named Assistant Director of Research of the Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa. Mr. Kempf has been with Alcoa since 1924.

At a luncheon meeting of the Illinois Section, American Society of Civil Engi-

neers held on December 17 two A.S.T.M. members were presented with Life Membership Certificates, as follows: F. A. RANDALL, Consulting Structural Engineer, Chicago, Ill., and F. M. RANDLETT, Vice-President and General Manager, Robert W. Hunt Co., Chicago, Ill.

A. B. KINZEL, Vice-President, Electro Metallurgical Co., New York, N. Y., has been elected chairman of the Engineering Foundation for the coming year. The Engineering Foundation was established in 1913 for "the furtherance of research in science and engineering and for the advancement in any other manner of the profession of engineering and the good of mankind."

PHILIP SPORN, Executive Vice-President and Chief Engineer, American Gas and Electric Service Corp., New York, N. Y., has been awarded the Edison Medal for 1945 by the American Institute of Electrical Engineers "for his contributions to the art of economical and dependable power generation and transmission." The medal was presented in a general session of the Winter Convention of the A.I.E.E. held January 21–25.

W. P. PUTNAM, President, Treasurer and Technical Director, Detroit Testing Laboratory, Detroit, Mich., was recently paid special tribute in recognition of his 50 years of service to chemists and chemistry by the Detroit Section of the American Chemical Society at its first "Annual Past Chairman's Night."

Two A.S.T.M. members have been nominated for district directors of the American Society of Civil Engineers, as follows: *Nominee for Director, District 1:* SHORTRIDGE HARDESTY, Partner, Hardesty & Hanover, New York, N. Y.; *Nominee for Director, District 2:* ALBERT HAERTLEIN, Professor of Civil Engineering, Graduate School of Engineering, Harvard University, Cambridge, Mass.

T. E. EAGEN, Chief Metallurgist, Cooper-Bessemer Corp., Mt. Vernon, Ohio, has been appointed chairman, Gray Iron Division, American Foundrymen's Association.

CHARLES H. GREENALL, Lieutenant Colonel, Officer in Charge, Laboratory Division, Frankford Arsenal, from October, 1942, through August, 1945, was recently awarded the Legion of Merit for services of conspicuous value. The Citation follows. "His exceptional leadership and initiative in the revolutionary development of recoilless artillery made possible the production of weapons which had far-reaching results in the combined effectiveness of the Infantry and Artillery. Through his energy, enthusiasm, and sound technical judgment, these weapons were rapidly and successfully developed under conditions of severe pressure. Lieutenant Colonel Greenall's outstanding achievements in directing not only this, but a great number of other significant projects, contributed greatly to our success in the war. He demonstrated at all times an unswerving devotion to duty and his high qualities of leadership were an inspiration to those whose work he directed and supervised." Before entering Ordnance Service Lieutenant Colonel Greenall was a member of the Staff at Bell Telephone Laboratories and was very active in A.S.T.M. work serving as Chairman of Committee B-5 on Copper and Copper Alloys. His future work will involve technical activities at the Franklin Institute in Philadelphia where he will be associated with the Director.

THORSTEN Y. OLSEN, President of Tinius Olsen Testing Machine Company, recently prepared a commemorative folder as a token of respect to his father, Tinius Olsen, Founder of the Company. This interesting folder includes an excellent picture and information of a biographical nature. He was a member of A.S.T.M. and took part in the work of numerous technical and scientific organizations. Issued on December 7, the folder also commemorates the 100th Anniversary of the birth of Tinius Olsen.

JOHN D. SULLIVAN, Assistant Director, Battelle Memorial Institute, Columbus, Ohio, and chairman of the Society's Committee on Refractories, was stricken in November with a ruptured appendix and resulting peritonitis while at Palmerton, Pa. After several weeks in the hospital there, he returned to Columbus, and a recent note indicates that after a few weeks in the Southwest he will be back at his office.

N. F. HARRIMAN, formerly Engineer of Tests of the Union Pacific Railroad Co., and for a great many years active in the work of the Federal Specifications Board, and later Vice-Chairman of the Federal Specifications Executive Committee, has retired from Government service. He was most recently Technical Assistant to the Director of Procurement, Treasury Department. A member of A.S.T.M. since 1902, he has been vitally interested in specifications work and was widely known to many A.S.T.M. members who had contacts with various committees of the Federal Specifications Board.

JOHN H. FRYE, who before his extended service in the Ordnance Department where he became Colonel, was Metallurgical Engineer with Columbia Steel and Shafting Co., Pittsburgh, Pa., has returned to the company and has been appointed General Manager of Sales. He had a very intensive period of Ordnance Department service in connection with materials and metallurgical specifications and procurement.

L. I. SHAW, formerly Development Engineer, Western Electric Co., Chicago, Ill., who has been very active in A.S.T.M., has retired. Mr. Shaw represented the Western Electric Co. membership and the sustaining membership for many years, and he was the chairman of a rather unique committee in the company which reviewed A.S.T.M. work and considered representation and activity from the company on a large number of committees in which Western Electric Co. is very actively interested. A. G. Johnson will take over Mr. Shaw's former duties.

The following is a corrected notice of an item which was noted in our December Bulletin:

J. LEWIS LUCKENBACH is now connected with Hardy S. Ferguson & Co., Inc., Consulting Engineers, New York, N. Y. as Designing Engineer. He was formerly with Anaconda Copper Mining Co., New York, N. Y., on structural and mechanical design.

## NECROLOGY

(Dates of death are given where available.)

A. E. FLOWERS, Research Engineer, The De Laval Separator Co., Poughkeepsie, N. Y. (December 3, 1945.) A member of the Society for over 40 years, his membership dating since 1914, Dr. Flowers had been extremely active in many phases of the work of the Society. Receiving his technical education at Cornell University and Union College where his Ph.D. degree was awarded in 1915, his industrial work was started with the Westinghouse organization; later he was Professor at the University of Missouri for a number of years, and still later at Ohio State. He served in the Signal Corps in World War I, and began his work with the De Laval Separator Co. in 1923. He was a member of a large number of technical and scientific organizations. In A.S.T.M. his technical committee affiliations indicated a wide diversity of interest, but perhaps particularly concentrated in the work of Committee D-2 on Petroleum Products and Lubricants where he had served as a member of the Advisory Committee, a large number of subcommittees and special groups. He had been a member of Committees B-3 on Corrosion of Non-Ferrous Metals and Alloys, and of D-9 on Electrical Insulating Materials for almost 20 years. In his death the Society loses a very loyal member who over the years contributed much to the advancement of the work in standardization and research.

C. F. CONN, Chairman of the Board, Giant Portland Cement Co., Philadelphia, Pa. (December 28, 1945.) Member since 1913. Mr. Conn, one of the leaders in the cement industry for many years, had been a member of A.S.T.M. since 1914, and served on Committee C-1 for a long period of time. At the time of his death he was vice-chairman of the committee. He had participated in the work of several subcommittees and at one time was chairman of the Cement Reference Laboratory group.

F. E. TWINING, Owner, The Twining Laboratories, Fresno, Calif. (October 18, 1945.) Member since 1912.

M. S. FALK, Consulting Engineer, New York Ordnance District, New York, N. Y. (November 26, 1945.) Member since 1905.

A. H. EMERY, President, The A. H. Emery Co., Stamford, Conn. (December 12, 1945.) Member since 1926.

C. B. KLINE, Chief Specification Examiner, Alloy, Carnegie-Illinois Steel Co., Pittsburgh, Pa. (November 9, 1945.) (Just Joined A.S.T.M. in 1945.)

CHARLES NURNBERG, President, Nurnberg Thermometer Co., Inc., Brooklyn, N. Y. (June 28, 1945). Member since 1924.

## New pH and Steel Samples Issued by the National Bureau of Standards

THE National Bureau of Standards, Washington 25, D. C., has inaugurated a series of standard samples for use in the preparation of buffer solutions of known pH values from 0 to 60 C., and in the calibration of instruments for the measurement and control of pH. Three standards of this series are now available, acid potassium phthalate, potassium dihydrogen phosphate-disodium hydrogen phosphate, and borax (sodium tetraborate decahydrate). The two phosphates are intended to be used together.

Four new standard steels have also been added to the list of standard samples.

Sample numbers and fees of the new standards are as follows:

Orders should give both the number and the name of the sample wanted. No samples of smaller size than those listed are distributed, and the remittance should accompany the order.

The Bureau now issues more than 300 different kinds of standard samples, comprising steels, irons, ferroalloys, nonferrous alloys, ores, ceramic materials, certain high-purity chemicals, hydrocarbons, paint pigments for color, oils for viscometer calibrations, certain reference standards, and melting-point standards. A complete list of the standards, fees, and other information is given in the Supplement to Circular C398, which can be obtained free of charge upon application to the Bureau.

| Sample Number | Material | Recommended Concentraton, moles per liter of solution | pH Value at 25 C. | Approx. Wt. of Sample, G. | Price per Sample |
|---|---|---|---|---|---|
| 185... | Acid potassium phthalate | 0.05 | 4.005 | 60 | $3.00 |
| 186... | Potassium dihydrogen phosphate (186-I) | 0.02 | 6.866 | 60 | 6.00 |
| | Disodium hydrogen phosphate (186-II) | 0.02 | | | |
| 187... | Borax | 0.01 | 9.177 | 30 | 3.00 |
| 139... | Steel (N.E. 8637) (approx. 0.5 Ni, 0.5 Cr, 0.17 Mo) | | | 150 | 3.00 |
| 152... | Steel (B.O.H.) (tin-bearing, approx. 0.04 Sn) | | | 150 | 2.00 |
| 155... | Steel (approx. 0.5 Cr, 0.5 W) | | | 150 | 3.00 |
| 156... | Steel (N.E. 9450) (approx. 1.4 Mn, 0.5 Ni, 0.4 Cr, 0.13 Mo) | | | 150 | 3.00 |

## Bulletin on Acid Open-Hearth Slag

RECENTLY issued by the Acid Open Hearth Research Association is its first bulletin covering "Acid Open Hearth Slag Fluidity and Its Significance." This covers the development of a fluidity test and the results of many plant data from numerous heats. The bulletin describes the application of the procedure developed and covers a typical heat where this control is used. There is a bibliography of some 80 references. The 60-page publication can be obtained from the Association, P. O. Box 1873, Pittsburgh, Pa., at $1 per copy.

A number of members of A.S.T.M. are active in the work of this Research Association including F. H. Allison, United Engineering and Foundry Co., *President;* F. C. T. Daniels, Mackintosh-Hemphill Co., *Secretary;* and R. C. Heaslett, Continental Foundry & Machine Co., *Treasurer.*

## Catalogs and Literature Received

GENERAL RADIO Co., Cambridge, Mass. Postwar Supplement to Catalog K, 58 pages. This catalog covers industrial instruments, resistors, capacitors, inductors, bridges, oscillators, and standard-signal generators, meters, amplifiers, and power supplies, parts, and accessories. The catalog also gives suggestions for ordering these items. Illustrated.

H-B INSTRUMENT Co., 2519 N. Broad St., Philadelphia 32, Pa. New sixteen-page catalog entitled "Temperature Control Instruments" describing in detail the complete H-B line of temperature control instruments which include relays (mercury plunger and sensitive types), thermostats, and Red-Top thermo-regulators.

W. H. & L. D. BETZ, Gillingham and Worth Sts., Philadelphia 24, Pa. A 171-page book ($8^1/_2$ by 11 in. page size, heavy paper cover) entitled "Betz Handbook of Industrial Water Conditioning." An up-to-date text for study, reading, or reference covering industrial water conditioning in all its phases. The book contains 54 chapters and is divided into two sections, the first section covering "Water Treatment" including discussions of the chemical and mechanical processes available for the treatment of water for industrial use, and the second "Water Analyses" dealing with impurities in water, how they originate, how they can be removed, and methods of analyses suitable for plant control. Includes charts and many other illustrations. Price: $1.00 per copy, postage prepaid.

BURRELL TECHNICAL SUPPLY Co., 1936–42 Fifth Ave., Pittsburgh 19, Pa. Four-page leaflet covering "Unit-Package" Tube Furnaces—illustrated. Also, a one-page leaflet describing McDanel Combustion Tubes Fired for High-Temperature Furnaces.

FISH-SCHURMAN CORP., 230 East 45th St., New York 17, N. Y. A four-page folder covering the Hoeppler Viscosimeter with an illustration and description of the instrument.

THE COMTOR Co., Waltham, Mass. Bulletin No. 32 entitled "Comtor Quick-Scanning Surface Comparator" describing and illustrating this Comparator. Also, Bulletin No. 31, eight pages, describing the Shock-absorbing Comtorplug Internal Comparator, with illustrations. This company's third booklet, "Comtorgage"—four pages, describes Series M for Precision External Gaging.

A. S. ALOE Co., Nineteenth and Olive Sts., St. Louis 3, Mo. The new catalog No. 102 "Laboratory Apparatus and Equipment for the Biological and Chemical Sciences" features a full range of apparatus for biological and related sciences as well as equipment for general chemical procedures. Includes more than 11,000 items, offers a very comprehensive listing of instruments and equipment for laboratories of chemistry, biology, and for allied fields such as public health, medicine, industrial hygiene, education, and for certain industrial applications. The apparatus listed is indicated as adapted to the more recent and modern techniques, and there are listed a number of items for procedures which have been used in comparatively limited fields of research and analysis. This extensive and profusely illustrated catalog includes a general index —sectional and detailed—and has some 1128 pages.

## Society to Cover Material Handling

ANOTHER new society has been formed to concern itself with material handling problems. At a recent meeting in Pittsburgh, Commander Boyd R. Lewis, U. S. Navy, described some of the Navy's problems in this field. T. O. English, Aluminum Company of America, is Temporary Chairman and Richard Rimbach of Pittsburgh, Temporary Secretary of this new group.

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